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THE DYNAMICAL THEORY

OF THE

FORMATION OF THE EARTH.

BY

ARCHIBALD TUCKER RITCHIE.

"Through faith we understand that the worlds were framed by the Word of God; so that things which are seen were not made of things which do appear."

HEBREWS xi. 3.

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HAVING, at length, entered within the more immediate domain of Geology, we shall be enabled to call in its powerful aid, to assist us in demonstrating the validity of those assumptions, which we have endeavoured to sustain in the preceding part of this work, and more especially in the last section. Those who may not have given much attention to the study of geology, or made themselves acquainted with the nature of the researches peculiar to this branch of science, may, perhaps, feel some surprise on perceiving us so disposed to lean, with such implicit reliance, on what it can do for us; but, when they reflect that the objects, with which geologists are conversant, are appreciable by the senses, can be seen, handled, and materially dealt with, and that these investigators have been

the most assiduous and systematic, perhaps, of scientific labourers, their surprise will be much abated; and will pass away altogether to give place to unshaken confidence, when they remember, that while those whose lot it was to convince mankind of the orbital revolution of this planet, had to appeal to objects external to the earth itself, and placed at vast distances in space, by whose relatively changing position they could manifest the rapid progress, in the clear blue vault of heaven, of the pedestal on which they alike stood, while the one asserted and the other denied the fact!—we, on the contrary, are constrained, from the altogether different nature of our subject, to seek, within the compass of the sphere itself, for our chief sources of proof; and to point the finger, not to the rising splendour of the sun, or to the waning lustre of a setting star, but *to the material vestiges of change upon the globe itself*, to the adamantine symptoms, which yet remain, of the presence, in bygone times, of great and unusual dynamical influences on its rocky surface; and by their means, and the assurance derived from ocular demonstration, to endeavour to convince our readers, *that protorotation was not coeval with the commencement of orbital revolution, but followed after a lapse of ages*, and produced upon the indurated, laminated, submarine crust of the sphere, which the intervening period had allowed to be prepared and fitted, those vast and manifold changes which might have been expected, when a non-rotating globe, possessing a level, concentric, rock-bound shell, was caused to rotate around its axis, and transformed, by the centrifugal impetus, into an earth diversified by continents and oceans, hill and dale, and all the pleasing variety which now meet the eye and render it so admirably adapted for its present inhabitants.

That geology, with its almost inexhaustible stores of authenticated facts, can supply us with the evidences which are now alone wanting to enable us to work out this great problem, we are fully persuaded; and, therefore, without further prelude, we shall call upon it to do so, while we trust the result will leave such impressions of conviction on the mind as shall neither be liable to be misinterpreted, nor capable of being set aside.

The *twenty-third* Theorem states "*That although a diversity*

of opinion prevails among geologists as to the origin, classification, and the nomenclature by which the greater groups of rocks composing the earth's outer surface are to be designated; nevertheless, an accordance has been come to as regards the unstratified amorphous masses, in contradistinction to all the stratified ones of every denomination.

"That they also concur in considering the primary rocks, besides being deficient in organic remains, to be more compact and crystalline in texture than the others, and generally more elevated in their positions. That they appear, in very many instances, to have been thrust up from beneath the strata, raising these up also, whether they have perforated or not wholly cut through them; in the former case remaining flanked by stratified masses, which repose upon them in evident inconformity."

What has just been said, will be sufficiently intelligible, without further illustration, to those who have paid any attention to geology; but, for the benefit of those who are not versed in that and kindred studies, we subjoin an occasional extract from some of the numerous authorities, to place the subject in a diversity of lights, in order that conviction may be more impressed upon the mind.

"Unstratified rocks"—Dr. M'Culloch observes—"have been produced from below the stratified. They are found below these, or above them, or intermixed in the form of masses, beds, and veins. The intermixture is attended by mechanical and chemical changes in the stratified rocks. They have been consolidated after fusion, and their structure is necessarily chemical."*

Sir H. de la Beche says—

"Our knowledge of the structure of the earth's crust is far from extensive, and principally confined to certain portions of Europe. Still, however, a mass of information has gradually been collected tending to certain general and important conclusions, among which the principal are—That rocks may be divided into two great classes, the stratified and the unstratified; that of the former some contain organic remains, and others do not; and that the non-fossiliferous

* Geology, vol. i. pp. 12, 13.

stratified rocks, as a mass, occupy an inferior place to the fossiliferous strata (or those which contain organic remains), also taken as a mass."

". . . . . In the accompanying table, rocks are first divided into Stratified and Unstratified, a natural division, or, at all events, one convenient for practical purposes, independent of the theoretical opinions that may be connected with either of these two great classes of rocks."*

Although Mr. Lyell, extends these two divisions to four, yet they may, with perfect propriety, be classified comprehensively into stratified and unstratified. The following is the description which Mr. Lyell gives:—

"I shall begin," says he, "by endeavouring briefly to explain to the student how all rocks which compose the earth's crust may be divided into four great classes, by reference to the different circumstances and causes by which they have been produced.

"The first two divisions, which will at once be understood as natural, are the aqueous and volcanic, or the products of watery, and those of igneous action at or near the surface.

"The *aqueous* rocks, sometimes called the sedimentary or fossiliferous, cover a larger part of the earth's surface than any others; and are stratified, or divided into distinct layers or strata. The term *stratum* means simply a bed, or anything spread out or *strewed* over a given surface, and we infer that these strata have been generally spread out by the action of water.

"The *volcanic* rocks are those which have been produced at or near the surface, whether in ancient or modern times, not by water, but by the action of fire or subterranean heat. These rocks are for the most part unstratified, and are devoid of fossils. They are more partially distributed than the *aqueous* formations, at least in respect to horizontal extension.

"But there are other two classes of rocks very distinct from either of those above alluded to, and which can neither be assimilated to deposits such as are accumulated in lakes or seas, nor to those generated by ordinary volcanic action. The members of both these divisions of rocks agree in being highly crystalline, and destitute of organic remains. The rocks of one division have been called plu-

* Manual, pp. 34, 35.

tonic, comprehending all the granites and certain porphyries, which are nearly allied in some of their characters to volcanic formations. The members of the other class are stratified, and often slaty, and have been called by some the *crystalline schists*, in which group are included gneiss, micaceous schist (or mica-slate), hornblende schist, statuary marble, the finer kinds of roofing slate, and other rocks afterwards to be described.

"Hence there are four great classes of rocks considered in reference to their origin; the aqueous, the volcanic, the plutonic, and the metamorphic."*

Professor Phillips, when comprehensively classing the rocks of which the earth's crust is composed, says—

"The arguments on which we rely for the proof of the sub-aqueous origin of all the stratified rocks may be thus summed up:—

"The stratified structure is that which is always assumed by successive depositions of sediments of water.

"The materials (clay, sand, limestone, &c.) composing the strata of the crust of the globe are exactly similar and in the same condition, or else very analogous to deposits now forming under water in various parts of the globe, and similarly associated.

"The organic contents of the rocks are such as admit of no other explanation, for they are mostly of marine or fresh water origin, and the few terrestrial *reliquiæ* which occur in them show, by various circumstances, that they were drifted from the land or overwhelmed by the sea. By combining all these considerations, we arrive at the positive conclusion, that all *the really stratified rocks* are of aqueous origin. But when we turn to the unstratified rocks, the same conclusion does not apply. Independent of the universal want of this unequivocal mark of watery action, ... the following circumstances are decisive:—

"The materials of which the rocks are composed, are neither similar to those now deposited by water, nor in a similar condition. They are not composed of sands, clays, or limestone, but of a variety of crystallized minerals. . . . . .

"In these unstratified rocks, organic remains do not occur, ... and, from the whole evidence, no doubt remains of the igneous origin of the crystallized and other unstratified rocks."†

* Elements, pp. 4, 15, 16. † Treatise on Geology, pp. 55, 56.

And again—

"It is remarkable that the lowest of all the known systems of stratified deposits should be at once the most extensive, the most nearly universal, the most uniform in mineral character, the only one from which organic life appears to be totally excluded, and in which the character of mechanical aggregation is the most obscure.

"The primary strata rest on unstratified, generally granitic rocks, so situated as to cut off all possibility of observation at greater depths. This granitic floor—this universal crystalline basis to the stratified rocks appears in many instances to have undergone fusion since the deposition of strata upon it, for veins pass from it into the fissures of these rocks. . . . . . It is enough for our present purpose that the general truth is recognised, that the stratified rocks, which are the products of water, rest universally on the unstratified crystalline rocks, which, through whatever previous condition their particles may have passed, have assumed their present characters from the agency of heat. Igneous rocks, then, rest below all the aqueous deposits."*

In corroboration of the foregoing position, with which it is intimately connected, we adduce what is stated in the *twenty-sixth* Theorem—"*That the granitic, trappean, serpentinous, and porphyritic descriptions of amorphous rocks generally constitute the nucleii or centres of mountain ranges, and together with their recumbent strata attain the greatest elevations throughout the world. And that conjointly they occupy a considerable portion of its terrestrial surface.*"

The following we offer as some of its evidences:—
Professor Phillips says—

"The high mountain districts generally exhibit in the central points, or along their axes, granitic and other unstratified rocks under all their strata, which slope away on all sides at high angles of inclination, descend to lower and still lower ground, and, finally, pass under the plains and more level regions, and are there covered up and buried under other superimposed strata. Very few parts of the world offer real exceptions to this general statement.

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* Treatise, pp. 94, 95, 69, 70.

And again—

"This leads directly to another very important law of the phenomena of disturbed stratification. The centre or axis of the mountain group, and consequently of the disturbing movement, is generally *seen* to be a mass of *unstratified rock*, such as granite, sienite, &c., which shows, by a variety of circumstances, that it was not deposited in water, but rather crystallized from igneous fusion."*

The following extract is from the pen of the graphic writer on the Old Red Sandstone:—

"I have often stood," says Mr. Miller, "fronting the three Ross-shire hills, Suil Veinn, Coul Beg, and Coul More, at sun-set in the fine summer evenings, when the clear light threw the shadows of their gigantic cone-like forms far over the lower tract, and lighted up the lines of their horizontal strata, till they showed like courses of masonry in a pyramid. They seem at such times as coloured by the geologist to distinguish them from the surrounding tract, and from the base on which they rest as on a common pedestal.

"The prevailing gneiss of the district reflects a cold-bluish hue, here and there speckled with white, where the weathered and lichened crags of intermingled quartz rock jut out on the hill sides from among the heath. The three huge pyramids, on the contrary, from the deep red of the stone, seem flaming in purple. There spreads all around a wild and desolate landscape of broken and scattered hills, separated by deep and gloomy ravines, that seem the rents and fissures of a planet in ruins, and that speak distinctly of a period of convulsion, when upheaving fires from the abyss, and ocean currents above, had contended in sublime antagonism, the one slowly elevating the entire tract, the other grinding it down, and sweeping it away." . . . . .

"In most of our hills," he continues "the upheaving agency has been actively at work, and the space within is occupied by an immense nucleus of inferior rock, around which the upper formation is wrapped like a caul, just as the vegetable mould, or the diluvium wraps up this superior covering in turn. One of our best known Scottish mountains—the gigantic Ben Nevis—furnishes an admirable illustration of this latter construction of hill. It is composed of three cones or rings of rocks, the one rising out of or over the

* Treatise, pp. 42, 43, 61.

other, like the cases of an opera glass drawn out. The lower one is composed of gneiss or mica slate, the middle one of granite, the terminating one of porphyry." While, "the elevating power appears to have acted in the centre, as in the case of Jorullo, in Mexico."*

"It is a familiar observation," says Dr. M'Culloch, "that granite forms the highest peaks and ridges of the most elevated mountains of the globe. The remark is, however, more common than true; it is certain that it constitutes many of these, but there are numerous mountains in the first class of elevations, that are formed of stratified rocks to the summits. Even where granite exists, it often forms only a portion of the highest points; the sides, at very great elevations, and many of the ridges and peaks, being still constructed out of the superincumbent strata. In a certain limited sense, it may also be said, that trap forms the higher summits in mountains and hilly regions; a remark very conspicuously true in some parts of the enormous ridges of South America."†

"Granite," according to the same author, "is one of the most universal rocks, forming some of the highest and most remarkable chains of mountains; being thus the most elevated, in absolute position, as it is supposed to be the lowest in a geological one. It is not, however, limited to such high chains as the Himalaya or the Alps, or even to the much lower ridges of Britain; since it also occupies many extensive tracts of comparatively level land. Hence it presents that diversity of picturesque outline formerly noticed; and if this variety sometimes results from disintegration, the same effects arise from its natural disposition. In these cases it forms tracts of various extent, though often constituting single mountains, or groups, or ridges, far separated from any analogous mass; as it sometimes also occupies places so small as not to be easily discovered."‡

Mr. Strickland, in his Memoir of Geological Investigations in Asia Minor, states—

"He did not observe granite *in situ*; but, on the authority of M. M. Fontanier, Texier, and other travellers, he believes that it constitutes the highest part of Ida, the Mysian Olympus, the Bithynium Olympus, Mount Diudynius, Mount Timolus, and Mount

* Old Red Sandstone, pp. 56, 58.

† Geology, vol. i. pp, 132, 133.

‡ Geology, vol, ii. p. 89.

Latmus. And, that the micaceous schists, and associated rocks, occupy a very important place in the geology of Asia Minor, forming nearly all the mountain chains that intersect that country."*

M. de la Beche says, on this subject—

"It must not be inferred, from the small space here dedicated to the inferior stratified rocks, that they are of little importance; for they are found to occupy a large portion of the earth's surface, wherever from denudations and disruptions of strata, or from the original absence of superincumbent rocks, they are exposed to our observation. Wherever observed, whether in Asia, North America, or Europe, they appear with constant general characters."

And a little further on, he adds,—"It would be tedious to enumerate the various situations where these rocks may be found. It may suffice to state, that there is scarcely any very large extent of country, where from some accident or other they are not exposed on the surface. They abound in Norway, Sweden, and Northern Russia; they are common in the North of Scotland, whence they stretch over into Ireland. In the Alps and other mountains they occupy the central lines of elevation, as if brought to light by the movements which have thrown up the different chains. They abound in the Brazils, and occur extensively in the United States. Our navigators have shown, that they are sufficiently common in the various parts of North America visited by them. They are found extensively in the great range of the Himalaya; Ceylon is in a great measure composed of them; and they would not appear to be scarce in various other parts of Asia. And in Africa, also, we know they are not wanting, though but so small a part of that continent has been yet explored with scientific views."†

In further confirmation of the more prominent effects of the centrifugal force, considered by the dynamical theory to have been the cause of the elevation of mountain chains, we recapitulate the *twenty-seventh* Theorem, and bring forward some of the evidences on which it is founded. That Theorem sets forth, "*That in mountain ranges certain axis of elevation are recognizable, while the outlines of the former frequently assume*

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* Proceedings of Geological Society, in Literary Gazette, 5th November, 1836, p. 714.

† Manual, p. 484, 485.

lengthened, irregular, conical forms, with one or more peaks; whose nucleii and apici usually consist of primary rocks. And that it may be considered as an established fact, both in geology and geography, that these ranges are, in general, comparatively less elevated in extreme latitudes."

The following are some of the evidences on which this Theorem is founded.

Professor Phillips says—

"By a careful study of the circumstances, we observe that these indications of disturbance augment continually toward the axis or centre of the mountain group; and that the direction of the movement has there been upwards. There has, in fact, been a real and violent *elevation* of the stratified crust of the globe, corresponding to the centre or axis of each mountain group," as shown by the diagram which follows* . . .

"Cases of *conical elevation* do occur, but rarely: *elliptical* ridges are more frequent; and the centres and axes of such being removed more or less completely, make round or elliptical *valleys of elevation.*

"Hardly any of the lofty mountain ranges on the face of the globe," he continues, "are entirely devoid of *gneiss* and *mica slate* uplifted upon an axis of unstratified granitic masses, so as to be inclined at right angles to the horizon. The great European basin is defined by irregular elevations of this kind from the Frozen Sea to the Atlantic: by the Uralian and Caucasian chains, the ranges of Asia Minor, Greece, South Italy, and the Atlas; the irregular Western Border of Spain, Ireland, the North of Scotland, and Scandinavia is of similar structure."†

"Mr. Martin" (observes Mr. Lyell) "in his work on the Geology of Western Sussex, throws much light on the structure of the Wealden, by tracing out continuously, for miles, the direction of many anticlinal lines and cross features; and the same course of investigation has been followed out, in greater detail, by Mr. Hopkins. The mathematician last named has shown, that the observed direction of flexure and dislocation in the Weald district coincide with those which might have been anticipated, theoretically, on mechanical principles, if we assume certain simple conditions, under which the strata were lifted up by an expansive subterranean force.

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* We would beg particular reference to this diagram.

† Treatise, pp. 60, 62, 71, 72.

He finds, by calculation, that if this force was applied, so as to act uniformly within an elliptic area, the longitudinal fissures thereby produced would nearly coincide with the outlines of the ellipse forming cracks, which are portions of smaller concentric ellipses, parallel to the margin of the larger one. These longitudinal fissures would also be intercepted by others running at right angles to them, and both lines of fracture may have been produced at the same time. In this illustration it is supposed that the expansive force acted simultaneously, and with equal intensity, at every point within the upheaved area, and not with greater energy along the central axis or region of principal elevation. . . . . . This accords well with that expressed by M. Thurnann, in his work on the Anticlinal Ridges and Valleys of Elevation of the Bernese Jura. . . . . . Among other results at which this author arrived, it appears, that the breadth of all the numerous anticlinal ridges and dome-shaped masses in the Jura is invariably great in proportion to the number of the formations exposed to view."*

Professor Phillips gives a parallel passage to that just quoted from Mr. Lyell's work, wherein he, also, relies on Mr. Hopkins's mathematical calculations and conclusions; and being given somewhat more in detail by Mr. Phillips, we beg reference to what is stated by him, although rather long for insertion here; nevertheless, we consider it essential to quote the concluding paragraph :—

"If the approximate accuracy of our assumptions be allowed, as applied to the crust of the globe, it appears from our investigations, that an elevated range, characterized by continuous systems of longitudinal and transverse fissures, referable to the causes to which we have been assigning such phenomena, could not be produced by successive elevations of different points, by the partial action of an elevatory force. In such elevations, fissures would necessarily diverge in all directions from the central points, so that parallel systems, such as have been mentioned above, could not possibly be thus produced. Every system of parallel fissures, in which no two consecutive fissures are remote from each other, must necessarily have had one simultaneous origin."†

* Elements, vol. ii. pp. 28—30, and the authorities there given.

† Treatise, pp. 266—270.

And lastly, on this branch of evidence, we find Mr. Miller alluding to the same upheaving principle, when describing, with his wonted powers of imagery, some examples in point from the scenes of his geological labours: would that we had had the benefit of the same clear and comprehensive sketching applied to more extended fields of research.

"The natural boundaries of the geographer," says he, "are rarely described by right lines. Wherever these occur, however, the geologist may look for something remarkable. There is one very striking example furnished by the North of Scotland. The reader, in consulting a map of the kingdom, will find that the edge of a ruler laid athwart the country, in a direction from south-west to north-east, touches the whole northern side of the great Caledonian valley, with its long straight line of lakes; and onwards, beyond the valley's termination at both ends, the whole side of Loch Eil and Loch Linnhe, and the whole of the abrupt and precipitous northern shores of the Moray Frith, to the extreme point of Tarbat Ness; a right line of considerably more than a hundred miles. Nor does the geography of the globe furnish a line better defined by natural marks. There is both rampart and fosse. On the one hand we have the rectilinear lochs and lakes, with an average profundity of depth more than equal to that of the German Ocean, and, added to these, the rectilinear lines of frith; on the other hand, with but few interruptions, there is an inclined wall of rock, which rises at a steep angle in the interior to nearly two thousand feet over the level of the great canal, and overhangs the sea towards its northern termination, in precipices of more than a hundred yards.

"The direction of this rampart and fosse, this Roman wall of Scottish geological history, seems to have been that in which the volcanic agencies chiefly operated in upheaving the entire island from the abyss. The line survives as a sort of foot-track, hollowed by the frequent tread of earthquakes, to mark the course in which they journeyed. Like one of the great lines in a trigonometrical survey, it enables us, too, to describe the lesser lines, and to determine their average bearing. *The volcanic agencies must have extended athwart the country from south-west to north-east.* Mark in a map of the island, all the better if it be a geological one, the line in which most of our mountain ranges stretch across from the German Ocean to the Atlantic; the line, too, in which our friths, lochs, and bays, on both the eastern and western coasts, and especially those

of the latter, run into the interior. Mark, also, the line of the geological formations, where least broken by insulated groups of hills; the line, for instance, of the old red sandstone belt, which flanks the southern base of the Grampians; the nearly parallel line of our Scottish coalfield, in its course from sea to sea; the line of the grauwacke, which forms so large a portion of the South of Scotland; the line of the English coal-field, of the lias, of the oolite, of the chalk, and, how, in this process of diagonal lining, if I may so speak, the south-eastern portion of England comes to be cut off from the secondary formation altogether; and, but for the denudation of the Valley of the Weald, would have exhibited only tertiary depositions. In all these lines, whether of mountains, lakes, friths, or formations, there is an approximation to parallelism with the line of the great Caledonian Valley; proofs that the upheaving agency from beneath must have acted in this direction from some unknown cause, during all the immensely extended term of its operations, and along the entire length of the island. It is a fact, not unworthy of remark, that the profound depths of Loch Ness undulated in strange sympathy with the reeling towers and crashing walls of Lisbon, during the great earthquake of 1755; and that the impulse, true to its ancient direction, sent the waves in huge furrows to the north-east and the south-west."*

That mountains and mountainous chains are, generally, more elevated the nearer they are to the equatorial region, we advert to the testimony afforded by the various graduated scales, or synoptic views of the most noted mountains of the world, and, also, to the following more general evidence, which incidentally occur in scientific works.

"It is well known," says the accomplished author of the Connexion of the Sciences, "that the continents at the equator, are more elevated than they are in higher latitudes."†

Professor Phillips, when endeavouring to disprove the assumption, that the globe might, by natural changes, be worn down by rains and waves, from a perfect sphere to a spheroid of rotation, after showing what would, under such a state of matters have been the case near to the equator, goes on to say:

"But nothing of the kind appears; on the contrary, the distribu-

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* Old Red Sandstone, pp. 137—139. † Page 56.

tion of land and water is excessively irregular, &c.; and the equatorial regions *include some of the highest mountains on the globe.*"*

What has hitherto been brought forward refers to *external* appearances only; endeavouring to prove by *them*, as far as they are available, that the mountain chains owe their elevations to the protorotation of the earth, and its dynamical consequences; and certainly, when the evidences which have been adduced from geological writers are compared with the effects which we anticipated would be produced by the dynamical forces, engendered by the first diurnal revolution of the earth, upon the concentric rocky masses of the primitive sphere, we are borne out in maintaining, that this external branch of the evidence goes a great way towards convincing us, that the peculiar structure of the mineral crust of the earth is due to the cause we anticipated, and which we have all along maintained it did. But we must now proceed, in further support of this position, to carry our investigations into *the more intimate formation* of those mountains, and into the *mineralogical structure* of the rocks which compose them. To effect this, we shall commence by adducing *the reasons we have for supposing, that the rocks of which they are composed have been moved en masse from the positions wherein they were originally formed.* In consequence of the simplicity and homogenity of the mineralogical composition, as well as the amorphous nature of the unstratified rocks, they do not, of themselves, present a sufficient prominency of character, on which to raise a conclusive chain of reasoning; but, fortunately, this difficulty is removed when we direct our enquiries to those stratified masses which immediately rest upon or overlie them; and with whose elevation they are so intimately associated that, by their means, we can reason regarding the primary rocks with a degree of certainty which banishes all doubt from the mind. We shall, therefore, pursue this method of argument.

By the *fourteenth* Theorem it will be seen, "*That the stratified rocks afford sufficient evidence of having been formed in succession, horizontally and tranquilly by deposition from*

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* Treatise, pp. 7, 8, which please see.

water; although, in many instances, bearing marks of the water having been gently undulated. That they differ in many respects from the primary amorphous masses." The concluding term of this Theorem being irrelevant to our present subject, it is not recapitulated.

As the evidences on which these opinions rest are of importance to our future argument, we shall give several of them at some length.

"Stratified rocks," says Dr. M'Culloch, "have been deposited from water. They have been produced from fragments, or from dissolved substances, or from both. They have been consolidated by mechanical forces, or by chemical actions, or by both. They were once horizontal in position, or nearly so, and their positions are now various. They were once continuous and straight planes, or nearly so, as far as their extent; and they are now bent, fractured, and separated. They were once unmixed with stratified rocks, and they are now intermixed with them. They were once, or oftener, below water, and they are now above it. They are repeated in consecutive and parallel order of the same, or different kinds. With rare exceptions, every stratum is of later origin than the one next below it. . . . . .

The term stratum, or bed, carries its own definition with it; its extent, according to the prolongation of its great opposing planes, being generally far greater than its thickness. A repetition of such beds forms a series of strata; and the term stratification implies the mode of their deposition, to whatever cause that may be attributed. The term stratification therefore implies a cause as well as a mode of form and disposition; and that cause is assumed or proved to consist in a deposition from water, of materials that have been suspended and dissolved in it."*

"The aqueous rocks," observes Mr. Lyell, "sometimes called the sedimentary, or fossiliferous, cover a larger part of the earth's surface than any others. These rocks are stratified, or divided into distinct layers or strata. . . . . .

"Fossil shells of forms, such as now abound in the sea, are met with far inland, both near the surface and at a great depth below it. They occur at all heights above the level of the ocean, having been observed at an elevation of from 8,000 to 9,000 feet in the Alps and

* Geology, vol i. pp. 12, 67.

Pyrenees, of more than 13,000 feet in the Andes, and above 16,000 feet in the Himalayas. (Geogr. Journal, vol. iv. p. 64.) These shells belong mostly to marine testaceæ, but in some places exclusively to forms characteristic of lakes and rivers. Hence it is concluded that some ancient strata were deposited at the bottom of the sea, and others in lakes and estuaries. . . . . .

"We have now pointed out one great class of rocks, which, however they may vary in mineral composition, colour, grain, or other characters, external and internal, may, nevertheless, be grouped together as having a common origin. They have all been formed under water, in the same manner as accumulations of sand, mud, shingle, banks of shells, reefs of coral, and the like, and are all characterized by stratification or fossils, or by both."

And again—

"Before entering into a more detailed investigation of the stratified rocks, it will be advisable to say something of the ordinary materials of which such strata are composed. These may be said to belong principally to three divisions, the arenaceous, the argillaceous, and the calcareous, which are formed respectively of sand, clay, and carbonate of lime. Of these, the sandy masses are chiefly made up of siliceous or flinty grains. The clayey, of a mixture of siliceous matter, with usually about one-fourth in weight of aluminous earth, and, lastly, the limestone or calcareous rocks consist of carbonic acid and lime.

"It has generally been said, that the upper and under surfaces of strata, or the planes of stratification are parallel. Although this is not strictly true, they make an approach to parallelism, for the same reason that sediment is usually deposited at first in nearly horizontal layers.

"The *ripple mark* so common on the surface of sandstones of all ages, seems to have originated in the drifting of materials along the bottom of the water in a manner very similar to that which may explain the inclined layers above described. This ripple is not entirely confined to the beach between high and low water marks, but is also produced on sands which are constantly covered by water."*

At another place he says—

"In short, the universal fluidity of the crystalline formations of the earth's crust, can only be understood in the same sense as the

* Please refer to the diagram given at this place in Mr. Lyell's work.

universality of the ancient ocean. All the land has been under water, but not all at one time; so all the subterranean unstratified rocks to which man can obtain access have been melted, but not simultaneously."*

And, finally, from this author—

"I may now recapitulate a few of the conclusions to which we have arrived; first, all the mechanical strata have been accumulated gradually; and the concomitant denudation has been no less gradual. Secondly, the dry land consists in great part of strata formed originally at the bottom of the sea, and has been made to emerge and attain its present height by a force acting from beneath. Thirdly, no combination of causes has yet been conceived so capable of producing extensive and gradual denudation as the action of the waves and currents of the ocean upon land slowly rising out of the deep."†

Dr. Buckland says—

"A great majority of the strata having been formed under water, and from materials in such a state as to subject their arrangement to the operation of the laws of gravitation; had no disturbing force interposed, they must have formed layers almost regularly horizontal, and therefore investing in concentric coats the nucleus of the earth, ... in which case we should have wanted that variety of useful minerals almost indispensable to the existence of man in a state of civil society, which this succession of different strata, by their partial verticality now present to us."‡

Professor Phillips thus expresses himself on the same subject:

"The essential principles admitted by both of these eminent men (Werner and Smith) are very simple; they affirm that the materials in the crust succeed one another in a particular order or series. This is nothing more than asserting generally, what is, in very many instances, found to be true locally, by the experience of miners, colliers, well-sinkers, quarrymen, and others."

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* Although we differ in our conclusions, yet we give these passages on account of the evidences they afford in favour of the point we are specially endeavouring to substantiate.

† Elements of Geology, vol. i. pp. 4—11, 22, 32, 41, 146, 191.

‡ Vindicæ Geologicæ, pp. 11, 12.

Again, after enumerating in detail the several descriptions of stratified rocks, he adds—

"And under these is granite, which nowhere appears to be stratified.

"Thus we have two classes of rocks, stratified and unstratified, which will require distinct examination."

"In each of the localities specified, the series of strata is found to be constant, not that every particular stratum is every where observed; but the *order in which they succeed one another, when present together, is never reversed.* This is consistent with all experience."

And in conclusion from this scientific writer—

"The true scale of geological chronology is that of the stratified rocks. According to the view previously advocated, the several systems of strata mark periods more or less exactly definable; the last, or supertertiary, which descends to the present era of the globe, being, as yet, one of the least defined in its limits. . . . . .

"At present, the chronology of the globe, starting from the origin of the stratified rocks, and including the whole series of successions of organic beings, and all the convulsive disturbances of the cooled and consolidated crust, recognises many successive periods of unknown duration. Neither does it appear possible to know their duration, or even the limits of error within which they fall. How, then, it may be asked, do geologists justify their confident assertions of the very great antiquity of particular rocks, as compared with the few thousand years of history? To this the reply is simple. Many of the ancient stratified rocks were formed in the sea, by processes perfectly similar to those which go on at this day; and, *in some cases*, we may believe not at all more rapid in their effects.

"The laminated sandstones often mark what appears to be the ripple of a gentle tide, and the successive deposits of agitated water; the shelly limestones sometimes prove very slow deposition of even a single layer of calcareous rock; the alternation of igneous and sedimentary rocks gives us the similitude of volcanic submarine eruptions. Now, if we compare, with the sedimentary strata of any particular period, the most similar products of the present day, we shall be impressed with the necessity of allowing a long period for the production of a single stratified formation.*

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* Treatise on Geology, pp. 30—33, 291, 292.

We are furnished, from another branch of science, with a remarkable corroboration of the general tendency to a striform arrangement of the mineral components of the earth's crust.

Mrs. Somerville, when treating of the form of the earth and its polar compression, employs the following as one of the evidences in favour of her argument:—

"The regularity with which the observed variation, in the length of the pendulum, follows the law of the square of the sine of the latitude, proves the strata to be elliptical, and symmetrically disposed round the centre of gravity of the earth, which affords a strong presumption in favour of its original fluidity."*

M. de la Beche says—

"In the accompanying table, rocks are first divided into stratified and unstratified, a natural division, or, at all events, one convenient for practical purposes.

"The same may, perhaps, also be said of the next great division; namely, that of the stratified rocks into superior, or fossiliferous, and inferior, or non-fossiliferous. The superior stratified, or fossiliferous rocks are divided into nine groups.

"In a descending series these are:—1. *Modern;* 2. *Erratic Block* Group; 3. *Supra-cretaceous;* 4. *Cretaceous;* 5. *Oolitic;* 6. *Red Sandstone;* 7. *Carboniferous;* 8. *Grauwacke; and* 9. *Lower Fossiliferous;* and underneath them all, the *Inferior or Non-fossiliferous* strata."†

M. de la Beche's work, from its design, being necessarily descriptive, should our readers desire fuller information from that correct geologist, they will require to peruse the work itself, as the stratified rocks and their embedded fossils occupy nearly the whole treatise.

With these facts, obtained from so many and from such unquestionable authorities, fresh upon the mind, let us recur to what is stated in the *seventeenth* Theorem.

"*That from the evidence afforded by the position and dislocation of the stratified masses, it is considered, that they have been elevated from where they were originally deposited, into*

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* Connexion of the Sciences, pp. 62, 63.

† Manual, pp. 34—37.

the inclined positions they now occupy; and by the agency of a force which acted from below upwards. And, that the time occupied in their elevation was very brief comparatively with that which elapsed during their formation.

The following are some of the evidences for these opinions: Mr. Lyell boldly commences—

"LAND *has been raised, not the sea lowered.* It has already been stated, that the aqueous rocks, containing marine fossils, extend over wide continental tracts, and are seen in mountain chains rising to great heights above the level of the sea. Hence it follows, that what is now dry land was once under water. But if we admit this conclusion, we must imagine either that there has been a general lowering of the waters of the ocean, or, that the solid rocks, once covered by water, have been raised up bodily out of the sea, and have thus become dry land. The earlier geologists embraced the former opinion, assuming that the ocean was originally universal, and had gradually sunk down to its actual level, so that the present islands and continents were left dry."

After enumerating the difficulties in which this involved them, Mr. Lyell goes on to say—

"Geologists, therefore, were at last compelled to have recourse to the other alternative, namely, the doctrine that the solid land has been repeatedly moved upwards or downwards,* so as permanently to change its position relatively to the sea. . . . . . These preliminary remarks will prepare the reader to understand the great theoretical interest attached to all facts connected with the position of strata, whether horizontal or inclined, curved or vertical. . . . . . The most unequivocal evidence of a change in the original position of strata is afforded by their standing up perpendicularly on their edges, which is by no means a rare phenomena, especially in mountainous countries. . . . . . Vertical strata, when they can. be traced continuously upwards or downwards for some depth, are almost invariably seen to be parts of great curves, which may have a diameter of a few yards, or of several miles.

"I may now recapitulate a few of the conclusions to which we have arrived : The dry land consists, in a great part, of strata formed originally at the bottom of the sea, and has been made to arrange and attain its present height by a force acting from beneath."

* This we of course dissent from.

And in conclusion, from Mr. Lyell, he continues, towards the end of his work—

"If we admit that solid hypogene rocks, whether stratified or unstratified, have in such cases been driven upwards, so as to pierce through yielding sedimentary deposits, we shall be enabled to account for many geological appearances otherwise inexplicable."*

Professor Buckland says—

"The actual position of these beds (the stratified masses of rock) is generally more or less inclined to the horizontal plane, though often under an angle almost imperceptible. By this arrangement many strata, affording numerous varieties of mineral productions, are made to emerge in succession on the surface of the earth."†

Professor Phillips asserts—

"We are fully convinced, that for broad and extensive formations of strata, composed of various successions of sands, clays, and limestones, variously stored with organic remains, there can be no risk of error in assuming, as a fact sufficiently proved, that they were deposited nearly level. Assured of this fact, as a basis of reasoning, we may proceed to enquire into the actual position of strata, as they are seen in the dessicated parts of the old oceanic bed which now compose our solid land. The most general condition of the stratified rocks of all ages is to be *not quite level*, but inclined to the horizon in some one direction, and at some certain angle, in each locality. . . . . .

"By a careful study of the circumstances, we observe, that these indications of disturbances augment continually towards the axis or centre of the mountain group; and that the direction of the movements has been there upwards. There has, in fact, been a real and violent *elevation* of the stratified crust of the globe, corresponding to the centre or axis of each mountain group. . . . . .

"We are thus led to associate the phenomena of the disturbance of strata with the eruption of crystallized rock from beneath. The latter, however, is not the cause of the former, but rather a concomitant effect of some general dynamical agency.‡

Professor Playfair, in his illustrations of his friend Mr. Hutton's Geological Theory, gives the following graphic passage:

* Elements, vol. i. pp. 94—96, 101, 102, 146, 147. vol. ii. pp. 370, 371.

† Vindic. Geol. p. 11.

‡ Treatise, pp. 59—61, 98.

"We have seen," says he, "of what material the strata are composed, and by what power they have been consolidated; we are next to enquire from what cause it proceeds, that they are now so far removed from the region which they originally occupied, and wherefore, from being all covered by the ocean, they are at present raised, in many places, 15,000ft. above its surface. Whether this great change of relative place can be best accounted for by the depression of the sea, or the elevation of the strata themselves, remains to be considered. Of these two suppositions, the former, at first sight, seems the most probable, and we feel less reluctance to suppose, that a fluid, so unstable as the ocean, has undergone the great revolution here referred to, than that the solid foundations of the land have moved a single fathom from their place. This, however, is a mere illusion. Such a depression of the level of the sea as is here supposed, could not happen without a change, proportionally great, in the solid part of the globe; and, though admitted as true, will be found very inadequate to explain the present condition of the strata. It is certain that many of the strata have been moved angularly, because that, in their original position they must have been all nearly horizontal. Loose materials, such as sand and gravel, subsiding at the bottom of the sea, and having their interstices filled with water, possess a kind of fluidity; they are disposed to yield on the side opposite to that where the pressure is greatest, and are, therefore, in some degree, subject to the laws of hydrostatics. On this account they will arrange themselves in horizontal layers; and the vibrations of the incumbent fluid, by impressing a slight motion backward and forward, on the materials of these layers, will very much assist the accuracy of their level. Now rocks, having their layers exactly parallel, are very common, and prove, their original horizontality to have been more precise than we could venture to conclude from analogy alone. In beds of sandstone, for instance, nothing is more frequent than to see the thin layers of sand, separated from one another by layers still finer of coaly, or micaceous matter, that are almost exactly parallel, and continue so to a great extent without any sensible deviation. These planes can have acquired their parallelism only in consequence of the property of water just stated, by which it renders the surfaces of the layers, which it deposits, parallel to its own surface, and, therefore, parallel to one another. Though such strata, therefore, may not now be horizontal, they must have been so originally; otherwise it is impossible to discover any cause for their parallelism, or any rule by which it can

have been produced. This argument for the original horizontality of the strata, is applicable to those that are now farthest removed from that position. Among such, for instance, as are highly inclined, or even quite vertical, and among those that are bent and incurvated in the most fantastical manner, as happens more especially in the primary schisti, we observe, through all their sinuosities and inflections, an equality of thickness and of distance among their component laminæ. This equality could only be produced by those laminæ having been originally spread out on a flat and level surface, from which situation, therefore, they must afterwards have been lifted up by the action of some powerful cause, and must have suffered this disturbance while they were yet, in a certain degree, flexible and ductile. Though the primary direction of the force which thus elevated them must have been from below upwards, yet it has been so combined with the gravity and resistance of the mass to which it was applied, as to create a lateral and oblique thrust, and to produce those contortions of the strata, which, when on the great scale, are among the most striking and instructive phenomena of geology. Great additional force is given to this argument, in many cases, by the nature of the materials of which the stratified rocks are composed. The beds of breccia and puddingstone, for instance, are often in planes almost vertical, and, at the same time, contain gravel-stones, and other fragments of rock, of such a size and weight, that they could not remain in their present position an instant, if the cement which unites them were to become soft; and therefore they certainly had not that position at the time when this cement was actually soft. Nothing can be more sound and conclusive than this reasoning. If some of the vertical strata are proved to have been formed horizontally, there can be no reason for not extending the same conclusion to them all, even if we had not the support of the argument from the parallelism of the layers, which has been already stated. The highly inclined position, and the manifold inflections of the strata, are not the only proofs of the disturbance that they have suffered, and of the violence with which they have been forced up from their original place. Those interruptions of their continuity which are observed, both at the surface and under it, are evidences of the same fact. It is plain, that if they remained now in the situation in which they were at first deposited, they would never appear to be suddenly broken off. No stratum would terminate abruptly; but however its nature and properties might change, it would constitute an entire and continued

rock, at least where the effects of waste and *detritus* had not produced a separation. This, however, is very far from being the actual condition of stratified bodies. Those that are much inclined, or that make considerable angles with the horizontal plane, must terminate abruptly where they come up to the surface. Their doing so is a necessary consequence of their position, and furnishes no argument, it may be said, for their having been disturbed, different from that which has been already deduced from their inclination. There are, however, instances of a breach of continuity in the strata, under the surface, that afford a proof of the violence with which they have been displaced, different from any hitherto mentioned. Of this nature are the *slips* or *shifts*, that so often perplex the miner in his subterraneous journey. . . . . The strata on one side of the *slip* continue parallel to those on the other; in other cases, the strata on each side become inclined to one another, though their identity is still to be recognized by their possessing the same thickness, and the same internal characters. These *shifts* are often of great extent, and must be measured by the quantity of rock moved, taken in conjunction with the distance to which it has been carried. All these are the undeniable effects of some great convulsion, which has shaken the very foundations of the earth; but which, far from being a disorder in nature, is part of a regular system, essential to the constitution and economy of the globe. . . . . .

"Though such marks of violence as have been now enumerated are common, in some degree, to all strata, they abound most among the primary, and point out these as the part of our globe which has been exposed to the greatest vicissitudes. At their junction with the secondary, phenomena occur, which mark some of the vicissitudes with astonishing precision; and from which Mr. Hutton concluded, that the primary strata, after having been formed at the bottom of the sea, in planes nearly horizontal, were raised, so as to become almost vertical, while they were yet covered by the ocean, and before the secondary strata had begun to be deposited upon them. . . . . .

"And on the whole, therefore, by comparing the actual position of the strata, their erectness, their curvature, the interruptions of their continuity, and the transverse stratification of the secondary in respect to the primary, with the regular and level situation which the same strata must have originally possessed, we have a complete demonstration of their having been disturbed, torn asunder, and

moved angularly, by a force that has, in general, been directed from below upwards."*

Sir John Herschel bears testimony to the same effect, when he thus expresses himself—

" Many of the strata, which thus bear evident marks of having been deposited at the bottom of the sea, and, of course, in a horizontal state, are now found in a position highly inclined to the horizon, and even occasionally vertical. And they often bear evident marks of violence, in their bending and fracture, in the dislocation of parts which were once contiguous, and in the existence of vast collections of broken fragments, which afford every proof of great violence having been used in accomplishing some, at least, of the changes which have taken place."†

Mr. Ansted seems to have been very clearly convinced of the presence of a very powerful elevating agency, acting from beneath, when he thus appropriately describes the symptoms of violent commotion and movement amongst the mineral masses, belonging to what he designates his first and second epochs. The passage, in his work, to which we allude, is as follows—

"But a time of much greater change was approaching," says he, " a time of disturbance, which should shake to their foundations all the solid and massive rocks that had been then deposited; and of subterranean movements, which, in their course, should break asunder the hardest and the strongest among these rocks; crushing and grinding, into small fragments, whole strata, that had become compact and closely consolidated, and crumpling, into complicated folds, the toughest and most unyielding beds, as if they had been layers of some soft material, carelessly squeezed in the grasp of a powerful hand.

" It is, indeed, impossible for words to express the complication of disturbance, or the amount of confusion, that has been produced, in some districts, by forces acting on the solid crust of the globe, between the close of what we have called the first epoch, and the commencement of the second; and yet all this was done with a cer-

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* Playfair's Illustrations of the Huttonian Theory, vol. i. pp. 56—67.

† Discourse on Natural History, Cab. Cyc. p. 284.

tain degree of order, and doubtless occupied a long period of time.* Volcanic eruptions have taken place in some districts, and their effect is seen in torrents of ancient lava, heaps of erupted ashes, and rocks chemically changed, by the intrusion of heated vapours charged with gases. In others, enormous cracks, extending for many hundred yards, or even for miles together, may be traced in the more brittle rocks; and the rocks themselves have been burnt, as in a furnace, by the boiling and bubbling mass of molten lava, which has been poured from beneath into such wide fissures. Sometimes extensive tracts, where the rocks are thinner and tougher, have exhibited these cracks, in systems of hundreds in number, parallel to one another; while here and there the intense fiery action from beneath has thrown up the surface into blisters and domes, which are often fractured at the top, and thus reveal the history of their elevation. Still more frequently, also, the irresistible subterranean force has snapped asunder the strata, as a violent blow would pierce through a few folds of paper, and one side of the broken bed has been lifted high in the air, or sunk into a deep hollow beneath. And if, as happened occasionally, the force was not sufficiently energetic to break up in this way the whole group of overlying matter, it might yet effect a no less striking result, raising up the strata upon a line, or on a point, and producing a saddle-shaped or a dome-like elevation, according to the circumstances of the case. All these effects, and all of them on the grandest scale, were produced in some way or other upon many of the old rocks towards the close of the first epoch of creation; and every geologist, familiar with the structure of our own island, could readily point to abundant examples of each particular disturbance above alluded to. Every coal-field is so split asunder and broken into small fragments by what are called "faults" (cracks and consequent disturbances of the strata) that they alone might be appealed to as sufficient proof; and, indeed, the very appearance of the smaller coal-fields of the middle of England, lifted as they are far above the great expanse of the new red sandstone, is due solely to these underground movements, which have borne to the surface portions of the

* The tenor of all our arguments will show, that we should feel disposed to express this idea as to the evidence "of a long period of time" having elapsed, in a very different way from Mr. Ansted. We, too, believe that a "long period elapsed," but it was *in the formation of the materials* of which these rocks are composed; the *time* occupied in elevating and transforming them into their present sites and actual condition, we believe did not exceed twenty-four hours common time.—AUTHOR.

carboniferous and lower strata, that would otherwise have been hidden. It is not unlikely that much of the general contour of the high ground of England, and many parts of Northern Europe, was originally marked out during the restless disturbances of this interval of violence. The districts occupied by the mountain limestone and the older rocks, at least, have probably, in later times, been disturbed only by movements affecting the general level of large tracts; and there cannot be a question as to the intensity and continuance of the forces acting beneath the surface, at that time, having been then much greater than any that have since affected that portion of the earth's crust exposed for investigation in our own island.*

Mr. Miller, when describing the upheaved position of the strata in the Great Caledonian Valley, thus expresses himself—

"The north-eastern portion of this rectilinear wall or chain runs, for about thirty miles, through an old red sandstone district. The materials which compose it are as unlike those of the plain out of which it arises, as the materials of a stone dyke, running half-way into a field, are unlike the vegetable mould which forms the field's surface. The ridge itself is of a granitic texture—a true gneiss. At its base we find only conglomerates, sandstones, shales, and stratified clays, and these lying against it in very high angles. Hence the geological interest of this lower portion of the wall. Imagine a large wedge forced from below through a sheet of thick ice on a river or pond. First the ice rises in an angle, that becomes sharper and higher as the wedge rises; then it cracks and opens, presenting its upturned edges on both sides, and through comes the wedge. And this is a very different process, be it observed, from what takes place when the ice merely cracks, and the water issues through the crack. In the one case there is a rent and water diffused over the surface, in the other there is the projecting wedge, flanked by the upturned edges of the ice; and these edges of course serve as indices to decide regarding the ice's thickness, and the various layers of which it is composed. Now, such are the phenomena exhibited by the wedge-like granitic ridge. The lower red sandstone, tilted up against it on both sides at angles of about eighty, exhibits in some parts a section of well-nigh two thousand feet stretching from the lower conglomerate to the soft unfossiliferous sandstone, which forms, in Ross and Cromarty, the

* Ancient World, London, 1847, pp. 106—108.

upper beds of the formation. There is a mighty advantage to the geologist in this arrangement. When books are packed up in a deep box or chest, we have to raise the upper tier ere we can see the tier below, and this second tier ere we can arrive at a third, and so on to the bottom. But when well arranged on the shelves of a library, we have merely to run the eye along their lettered backs, and we can thus form an acquaintance with them at a glance, which in the other case would have cost us a good deal of trouble.

"Now, in the neighbourhood of this granitic wedge, or wall, the strata are arranged, not like books in a box—such was their original position—but like books on the shelves of a library. They have been unpacked and arranged by the uplifting agent; and the knowledge of them, which could only have been attained, in their first circumstances, by perforating them with a shaft of immense depth, may now be enquired simply by passing over their edges.

A morning's saunter gives us what would have cost, but for the upheaving granite, the labour of a hundred miners for five years."*

"If the highly inclined position of the strata," says Dr. M'Culloch, "were not in itself a proof of their elevation, evidences of motion are found in a great number of phenomena. In their curvatures we find proofs of disturbance; we find even more decided evidence to the same purpose in their fractures. But when we see that these fractures are often accompanied by a separation of the parts which were once continuous, that one portion of a stratum occupies a higher or a lower place than another, and that this separation is often attended by a difference in the angle of inclination of the separated parts, we have every proof that can be desired, of an alteration in the positions of stratified rocks since the period at which they were formed or consolidated. . . . . . It is well known that certain marine worms which live in sand, and which inhabit straight tubular shells, invariably penetrate the sand in a vertical direction. Analogous fossils found in the horizontal strata, preserve the same vertical position. But where such strata are inclined, the position of the animal is no longer vertical to the horizon, although it preserves its perpendicular position to the stratum; indicating the change of place which that has undergone since it formed a part of the ocean's bed. The same conclusion follows, from considering the positions of leaves in the strata that accompany coal. In these cases, the flat side of the leaf

† Old Red Sandstone, pp. 139—141.

is invariably parallel to the plane of the stratum, although it may often be vertical to the horizon; a position, it is sufficiently plain, in which such substances could not have been deposited from water. The general elevation of strata from the bottom of the ocean being thus proved, it remains to enquire," &c. &c.*

These numerous and concurring evidences, to which may be added, with perhaps equally convincing effect, the sectional drawings of suits of formations on Mr. Knipe's geological maps of the British Islands, exhibiting at a view, and in the most faithful manner, the effects of the elevating power upon the stratified masses, will sufficiently testify that the *stratified* masses are considered *to have been moved* from the horizontal posture in which they were deposited, to the elevated positions they now occupy, by a force which acted *from below upwards*. And as they repose on the *unstratified rocks*, it follows, as an axiom, *that the latter must likewise have been moved from where they were formed, before those which overlie them could have been elevated by a force acting in the direction just mentioned*. As this direction *from below upwards*, coincides precisely with that of the centrifugal impetus—originating from rotation—which would necessarily be impressed on these associated masses, which remained at rest as long as the earth had not been caused to revolve around its axis, we claim as its just privilege; *that the dynamic force thus engendered may, for the present, be allowed a place amongst those which are considered competent to have occasioned the removal of the concentric mineral masses from the recumbent posture in which they were formed, to the elevated positions they now occupy;* and in the sequel we shall bring forward proof to show, that *to this force exclusively must be attributed that stupendous result*, and whose successful establishment will prepare the way for clearing up other points from their present uncertainty.

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* Geology, vol. i. pp. 88—90.

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XX.

Evidences to prove, that the non-rotatory sphere was circumbounded by water—astronomical proof—geological proof. This fact, combined with what was established in previous chapters, leads to the conclusion, that violent movement, therefore much friction, and consequently great heat, would necessarily ensue amongst the rocky masses of the earth's crust. The characteristics of Friction enquired into, and the Breccia which would result, when mineral formations, abounding with calcareous material, were subjected to its influence under water. The great Breccia and Conglomerate formations geologically described, and shown to correspond with that which the Dynamical Theory requires for its perfection, should be found to exist. Some of the more special uses which they were designed to accomplish made manifest. The Coal Measures protected by the Conglomerate and Breccia from fusion and denudation. The nucleii of mountain ranges the resultant foci of heat engendered by friction. Geological proof of this, deduced alike from the mineralogical structure of the rocks composing these elevations, and from the existing symptoms of fusion, evidenced by the altered condition of their contiguous strata.

THE several points which the successful issue of our argument in the last chapter will enable us now to investigate, though numerous, are all equally worthy of notice, while they simultaneously press upon our attention; but we shall follow what may be considered to have been their sequence in the order of time, by endeavouring to prove, first, *that the primeval world was enveloped by an illimitable ocean, under whose atmosphereless waters the elevating revolution just established took place.* With this view we shall begin, by having recourse to the *tenth* Theorem, which states—"*That according to investigations made by M. de la Place, for the purpose of demon-*

strating the stability of the equilibrium of the sea, it has been discovered, that the equilibrium of the sea must be stable, and its oscillations continually tending to diminish, if the density of its waters be less than the mean density of the earth; and that its equilibrium would not admit of subversion, unless the mean density of the earth was equal that of water or less."

Looking more minutely into the evidences which supply this general assertion, we find Professor Playfair thus expressing himself—

"La Place has treated a subject connected with the tides, that, so far as we know, has not been entered upon by any author before him. This is the stability of the equilibrium of the sea. A fluid surrounding a solid nucleus may either be so attracted to that nucleus, that when any motion is communicated to it, it will oscillate backwards and forwards till its motion is destroyed by the resistance it meets with, when it will again settle into rest; or it may be in such a state, that when any motion is communicated to it, its vibrations may increase, and become of enormous magnitude. Whether the sea may not, by such means, have risen above the tops of the highest mountains, deserves to be considered; as that hypothesis, were it found to be consistent with the laws of nature, would serve to explain many of the phenomena of natural history. La Place, with this view, has enquired into the nature of the equilibrium of the sea, or into the possibility of such vast undulations being propagated through it. The result is, that the equilibrium of the sea must be stable, and its oscillations continually tending to diminish if the density of its waters be less than the mean density of the earth; and that its equilibrium does not admit of subversion, unless the mean density of the earth was equal to that of water, or less. As we know, from the experiments made on the attraction of mountains, as well as from other facts, that the sea is more than four times less dense than the materials which compose the solid nucleus of the globe are at a medium,* the possibility of these great undulations is entirely excluded; and, therefore, says La Place, if, as cannot well be questioned, the sea has formerly covered continents that are now much elevated above its level, the cause must be sought for elsewhere than in the instability of its equilibrium."†

* Confirmed by the *eighth* Theorem.

† Playfair's Works, vol. iv. pp. 302—305.

Mrs. Somerville confirms this when she asserts that—

"It is also necessary for the equilibrium of the ocean, that its density should be less than the mean density of the earth, otherwise the continents would be perpetually liable to inundations from storms and other causes."

And again—

"One of the most remarkable circumstances in the theory of the tides is the assurance that, in consequence of the density of the sea being only one-fifth of the mean density of the earth, and the earth itself increasing in density towards the centre, the stability of the equilibrium of the ocean can never be subverted by any physical cause. A general inundation, arising from the mere instability of the ocean, is, therefore, impossible."*

If, while the impressions arising from these evidences are vividly on the mind, we again refer to the *thirteenth* Theorem, we shall find it therein recorded, in conformity with this opinion of M. de la Place himself, and on the authority of a host of other witnesses, whose testimony cannot possibly be set aside—"*That wherever any considerable portion of the earth's surface has been examined by geologists, it has invariably afforded proofs of having been, at one time, submerged in the waters of the ocean.*"†

Now this evidence appears to be very perplexing, when we take into account what has just been established, with respect to the equilibrium of the ocean, and the impossibility of its overflowing the land, as the two are at present constituted. It places us, as well as M. de la Place, in a dilemma, from which we can be extricated only by one of the two following conclusions; either that those portions of the earth—and it must be remembered, they embrace parts of its whole surface—which afford such unequivocal symptoms of having been formerly submerged in the ocean, *have risen above it in detached portions, at different periods*, whilst corresponding depressions

* Connexion of the Sciences, pp. 56, 114.

† It will be remembered, that we have already, in a previous part of this Treatise, had occasion to adduce the evidences pertaining to this Theorem, consequently we do not here recapitulate them.

of surface took place in other localities. Or, that they were *all synchronously elevated and depressed, as the effects of one great and general revolution, while as yet the earth was surrounded by the primeval ocean.*

We shall leave the supporters of the former opinion to bring forward their evidence at leisure, without adding to their difficulties by a single observation; while we entirely rely on the well-grounded confidence, that every succeeding fact which may be brought to light, will tend further to corroborate the opinion maintained in this theory, namely, *that there was only one general elevation of the continents and mountains of the world; and one simultaneous depression of its ocean beds and valleys; being the first and most important results of the centrifugal force, occasioned by the earth's protorotation,* and which, in turn, was caused by the formation of the light, and its division from the darkness—positions which we trust, by every successive step in the progress of this work, to render more and more apparent and convincing. We repeat, therefore, our firm belief, *that there was only one general formation of continents and mountains, with their corresponding oceanic hollows and valleys on the face of the globe we inhabit; and that this took place on the first day of the Mosaic week.* In due time we shall prove both of these positions; thereby leading to the undeniable conclusion, *that previously to these elevations and depressions, the whole surface of the earth was synchronously submerged in the water of the primitive ocean.*

To this conclusion the DYNAMICAL Theory leads us. The same final result may, we think, be come to, by impartially comparing the opinions given by geologists, on points connected with this particular branch of their researches. Some of these conclusions we have already given, but are constrained to repeat them here, as they, likewise, afford evidence on the question more immediately under consideration.

Professor Phillips says—

"Over immense tracts of the earth's surface, the angle of inclination is extremely moderate; more than three-fourths of the surface of Europe (and probably of other continents) is occupied by strata, which in common language may be said to be nearly horizontal.

. . . . . Among the Alps and Pyrenees, the strata, which in every part of their surface were originally very little inclined, and which, at a distance from the mountains retain nearly their original position, are thrown into various disturbed positions; the local effect of violent couvulsions. By a careful study of the circumstances we observe, that these indications of disturbance augment continually towards the axis or centre of the mountain group; and that the direction of the movements has been there upwards. There has, in fact, been a real and violent *elevation* of the stratified crust of the globe, corresponding to the centre or axis of each mountain group.* . . . .

" We are thus led," he continues a little further on, " to associate the phenomena of the disturbances of the strata with the eruption of crystallized rock from beneath; but the latter is not exactly the *cause* of the former, but rather a concomitant effect of some general dynamical agency. . . . . . Once acquainted with this relation of the two classes of rocks, we are in possession of a clue to guide us through all the mazes of local geology; for it is equally true of small elevations of strata, as of all mountain chains, that the most general condition observable, is the mutual dependence of these disturbances, and the eruptions of unstratified rocks."†

The whole tenor of these passages clearly indicates, that while the elevations of these centres or axes of elevation have been the immediate cause of the *alteration* and *disturbance* of the once horizontal strata, they were themselves impelled to become so, as the co-effect of some general and deep-seated force, which caused them to protrude, and in doing so, to elevate and to disturb the once superincumbent stratiform masses; and that this may be considered as a general rule, applicable to the whole surface of the earth, wherever mineral masses are found disturbed and elevated.

Then, from an entirely different source—the result of dexterously applied mathematical investigation to the probable origin of the inequalities of the earth's mineral crust—we have a remarkable corroboration of the same views; with the addition, that this method seems to repudiate the possibility of "an elevated range, characterized by continuous systems of

* This he illustrates by a diagram, which it would be well to consult.

† Pages 60, 61.

longitudinal and transverse fissures being produced by successive elevations of different points, by the partial action of an elevatory force;" but that "every system of parallel fissures, in which no two consecutive fissures are remote from each other, must necessarily have had a simultaneous origin."*

To these two distinct sources of evidence, which prove, that throughout the whole terraine surface, disturbances of the strata may be considered to be intimately associated with the irruptions of unstratified rocks; and, that "continuous systems must have had a simultaneous origin;" there may be added, the late hypotheses of M. Elie de Beaumont, by which the principal mountain chains, throughout the world, are grouped into systems, each supposed to have "a common origin," and some of which embrace a vast extent of geographical area; for instance—

"M. de Beaumont," says Professor Phillips, "assigns to this period (that of the *cretaceous* system) his Pyreneo-Appennine system of convulsion, the elevation of the Pyrennees, Carpathians, Northern Appennines, Dalmatia, and the Morea, in lines ranging parallel to a great circle on the sphere, through Natchez, on the Mississippi, and the Persian Gulf. It appears, also, that some disturbances, which happened during the cretaceous era, are traceable in Mont Viso and theWestern Alps."†

At the same time we particularly direct attention to the *assumed original horizontality of the strata,* whose elevation is thus sought, in these various speculations, to be accounted for; while we need hardly remind our readers, of the admitted contemporaneousness of the geological formation of the great stratiform masses of the earth's crust, wherever these have hitherto been examined.

Taking, therefore, all the data which we have here collated into account, we are constrained to come to the conclusion, that that which is intimately associated with, and indicates a disturbing cause of the once horizontal surface of strata, admitted to be contemporaneous in their formation, which is alike common "to small elevations and to mountain chains,"

* Phillips, p. 270, from Mr. Hopkins's calculations. † Treatise, p. 160.

but which "could not be produced by successive elevations of different points by the partial action of an elevatory force;" and yet is declared by others to have been in violent operation over immense tracts of territory, and, indeed, shown to have been thus prevalent at certain parts everywhere over the whole known surface of the earth—must have been contemporaneous.

There could, in reality, have been only ONE GRAND AND SYNCHRONOUS elevation of HILLS, MOUNTAINS, MOUNTAIN CHAINS, and CONTINENTAL RIDGES throughout the world.

In this opinion we are confirmed when we reflect, that besides the more *local* indications of disturbance which the causing force has occasioned, it has afforded enduring symptoms of having acted on a *more general and comprehensive scale* than what the writers of these conceptions seem to have contemplated or provided for. We allude to the continental ridges and to the greater elevation of the continents and mountain chains within the tropics, and the nearer these approach to the equator, where the force was evidently at its maximum.

This prominent peculiarity; this evidence of the force having had a *maximum* and *minimum*, corresponding to parallels of latitude, and profound curvatures by meridians of longitude, whose depth seems to be inversely as the degrees of the former, cannot be accounted for; has never, as far as we know, been attempted to be accounted for by any other theory, except by this, which attributes these effects to a world put into rotatory motion, with an angular velocity of fifteen degrees per hour, after its crust had been so constructed by deposition, and consolidated by duration, as to admit of being broken up by the centrifugal force brought to bear upon it; and capable of being transformed into hill and dale, mountains and valleys, continental ridges and oceanic hollows, with all the variety of mineral structure, and central amorphous masses, which are now found to constitute the nucleii of elevated ranges, with stratified envelopes reclining, like stony drapery, upon their huge flanks and shoulders.

Recurring to the position which we established in a previous chapter, that the undermost masses of the non-rotating sphere, from being the most dense, became the central and

most elevated parts of the various formations in the earth's present geological economy; we shall next proceed to enquire into the immediate results, or natural consequences, of this remarkable transformation, occasioned by the centrifugal impetus of the first rotation.

The most obvious idea which presents itself to the mind, is, that *motion* equal to the change of relative position *must* have taken place during the process. One of the first and most important effects of motion, or movement, amongst masses in contact with one another is FRICTION—a property arising from the imperfect smoothness of surfaces, and which impedes the motion of bodies whose surfaces are in contact.* As we shall require to know something of the nature and effects of this property—now introduced to our notice for the first time—we shall retard the general argument until we make ourselves somewhat better acquainted with it. "*In friction,*" the *eighty-third* Theorem informs us, "*the amount of the resistance increases according to the roughness of the surfaces, and the force with which these, moving upon one another, are pressed together. Surfaces being equal, a double pressure will produce a double friction. That these results are but slightly affected by the velocity with which the surfaces move upon each other. And, therefore, any body moving under the effects of a given force will, in proportion to the increase of the asperity and pressure, be the more speedily deprived of its velocity, and reduced to a state of rest. And that* FRICTION *is a great source of heat independently of fire or flame.*"

From this it will appear obvious, that when an uneven surface is made to slide upon another, under the influence of great force applied to the movement of heavy masses, one of the most immediate tendencies is to overcome, wear away, or grind down whatever asperities may impede the progress of the moving body. In the event of either or both of the masses which present such asperities being composed of materials prone to split and break into detached pieces, they would most probably, by doing so, yield to the greater force; and the fragments, by moving along with the mass of greatest velocity, would, as

* Mechanics, in Cab. Cyc. p. 262.

far as they were capable, facilitate the general movement. The intensity of these results would be much increased, were the mass of greatest velocity forcibly ejected, or thrust through amongst others which had been formerly incumbent upon it; while comminution, and disintegration of the substances brought into contact, and the evolution of fierce heats would be the general consequence of the whole operation; and, finally, if this were done under water, and amongst calcareous and arenaceous materials, there would be produced a tenacious cement capable of binding the whole together into one firm and inseparable mass.

Now, this is precisely what has taken place in the great cementing processes of the world, which Nature's Architect designed and wholly executed. By referring to the *hundred and second* Theorem, it will be perceived, "*That* CARBONIC ACID *abounds in nature, and appears to be produced under a variety of circumstances. It composes* 44-100*ths of the weight of limestone, marble, calcareous spar, and other natural varieties of calcareous earth. That on the application of a pretty strong heat to the various kinds of limestone (carbonate of lime), the carbonic acid is evaporated and the lime remains. And, that the basis of all effectual cements used in constructing works designed to be either occasionally or permanently under water, must be made from the hydrate of lime.*"

With this information on the mind, let us turn to the *twenty-second* Theorem, in which it is stated, "*That thick and extensive beds of breccia and conglomerate, in which the fragments are generally united by calcareous and other mineral substances, are found to intervene amongst the various series of the older and the secondary stratified masses, especially in the vicinity of mountain chains, and above and below the coal formations.*"

This clear but concise view of the case ought to make us fully aware of the wisdom and harmony of the plan, which provided such abundance of materials for the formation of those great cementing processes, which combined, by the wonder-working hand of the Creator, the apparently heterogeneous materials of the earth's outer crust into one great, consistent, and firmly united whole.

As there may be many not sufficiently acquainted with the nature of these well known conglomerate and breccia bindings

of the earth, to be capable of appreciating the perfection and adaptation of their construction; in which the masonic art seems to have been anticipated, and all that was necessary accomplished in one great and simultaneous day's work, over the whole surface of the earth, we have much pleasure in subjoining the following extracts, in order that their minds may, by their contemplation, receive sensations of as much pleasure and admiration as we ourselves have done.

Professor Phillips says—

"Along the flanks of the Grampians, Lammermuir, and Cambrian mountains, the *old red sandstone formation* is chiefly a rude conglomerate of pebbles, torn by violent floods from the neighbouring high ground.

"We find, in fact, round all the mountain ranges, which for other reasons were presumed to have been uplifted before the carboniferous epoch began, some of the most remarkable conglomerate rocks which occur in the British strata. The character of these conglomerates, too, varies in direct relation to the proximity of the mountains. . . . . .

"The great qualities of those sediments imply, probably, some great physical changes of land and water, in situations not far removed. . . . . ."

And lastly from this author—

"When we behold conglomerate rocks, which hold fragments of other earlier deposits, and in these fragments the organic remains of still earlier periods, which had already undergone their peculiar mineral changes; when we collect the history of such an organic form—its existence in the sea—its sepulchre in a vast oceanic deposit of limestone—the induration of this rock—its uplifting by subterranean forces—the rolling of it into pebbles—the reunion of them into a totally different substance—it is evident that no greater folly can be committed, than to think to serve the cause of truth by contracting the long periods of geology into the compass of a few thousand years."*

M. de la Beche says—

"If we look to the Alps we find, on all sides of that chain, beds

* Treatise, pp. 104, 115, 116, 293.

of various depths of sandstone and conglomerates, forming a whole of very considerable thickness. If we also attentively examine the component parts of the sandstones and conglomerates, we find that the former are, generally, mere comminuted portions of the latter, and that both have been derived from the Alps. The whole is evidently a detritus of the Alpine rocks, and in it organic remains are by no means common, though they occur in certain situations. Such general appearances would seem to indicate a common origin, and that origin to be the Alps themselves. Rolled and comminuted detritus of the kind may either be derived by the continued action of what are termed actual causes, or some more violent exertion of forces, which, producing rapid motions in water and greater destruction of the land, should accomplish a far greater quantity of work in a given time. . . . . .

"It has been observed by M. Elie de Beaumont, that the calcareous portions of these regions of the Alps are separated from the older and non-fossiliferous rocks by a sandstone more or less coarse, which passes into conglomerate."

And again, a little further on, he says—

"I cannot avoid connecting this conglomerate (that on the shores of the Magra) and that on the Lake of Como, with the conglomerates and sandstones of the Valloisine and other parts of the western Alps, and referring them to the same epoch of formation—one in which water, with certain velocity, ground down portions of pre-existing rocks, and which was attended with a state of things when a great abundance of carbonate of lime was deposited.

"Taken as a mass, this group may be considered as a deposit of conglomerate, sandstone, and marl, in which limestones occasionally appear in certain terms of the series; sometimes one calcareous deposit being absent, as the muschelkalk is in England; sometimes the Zechstein, as in the east and south of France; and sometimes both being wanting, as in Devonshire. The conglomerates, or todtliegendes, commonly occupy the lowest position, though conglomerates are occasionally noticed higher in the series; the sandstones form the central part, and the marls occur in the higher place." . . . . .

And in conclusion, from M. de la Beche—

"Another circumstance also lends probability to this view, (namely, that the eruption of the trappean rocks caused the conglo-

merate), and that is, the occurrence of pebbles cemented in certain inferior beds by a kind of semi-trappean paste, containing crystals of a kind of felspar. Such a cement might possibly have resulted from the upburst of igneous rocks, accompanied by various gases beneath a mass of water; when some of the matter may have combined so as to form a cement. Without some such hypothesis the cement seems of very difficult explanation."*

Mr. Lyell, when explaining the nature and origin of the stratified formations, expresses himself thus with respect to that particular description of rocks, to which our attention is at present directed:—

"At various heights and depths in the earth, and often far from seas, lakes, and rivers, we meet with layers of rounded pebbles, composed of different rocks mingled together. They are like the shingle of a sea-beach, or pebbles formed in the beds of torrents and rivers, which are carried down into the ocean wherever these descend from high grounds bordering a coast. There the gravel is spread out by the waves and the currents over a considerable space, but during seasons of drought the torrents and rivers are nearly dry, and have only power to convey fine sand or mud into the sea. Hence alternate layers of gravel and fine sediment accumulate under water, and such alternations are found by geologists in the interior of every continent."†

Mr. Lyell here refers to a fine exemplification, illustrated by a diagram of a case in point at the base of the Maratime Alps, where a vast succession of slanting beds of gravel and sand may be traced a distance of no less than nine miles in a straight line; and further on, proceeds to say—

"The most unequivocal evidence of a change in the original position of strata is afforded by their standing perpendicular on their edges. . . . . . Thus we find, on the southern skirts of the Grampians, beds of puddingstone alternating with thin layers of fine sand, all placed vertically to the horizon. When Saussure first observed certain conglomerates in a similar position in the Swiss

* Manual of Geology, pp. 210, 323, 329, 400, 404.

† Although we differ in opinion as to the *cause* of these accumulations, we give the evidence as to the facts.

Alps, he remarked that the pebbles, being for the most part of an oval shape, had their longer axis parallel to the plane of stratification; from which he inferred that such strata must first have been horizontal, each oval pebble having originally settled at the bottom of the water, with its flatter side parallel to the horizon, for the same reason that an egg will not stand on either end if unsupported.

"Strata of sand and gravel, sometimes bound together into a solid rock, are found in great abundance around the confines of lacustrine basins, containing, in different places, pebbles of all the ancient rocks of the adjoining elevated country; namely, granite, gneiss, mica-schist, clay-slate, porphyry, and others. But these strata do not form one continuous band around the margin of the basin, being rather disposed, like the independent deltas which grow at the mouths of torrents, along the borders of existing lakes."

And further on, when treating of the old red sandstone, he states—

"The beds next below the yellow sandstone are well seen in a large zone of old red, which skirts the southern flank of the Grampians, ... where the entire mass of strata are several thousand feet thick, and may be divided into the following principal masses—1st. Red and mottled marls; 2nd. Conglomerates of vast thickness.

"The eastern chain of the Andes consists chiefly of sandstones and conglomerates of vast thickness, the materials of which are derived from the veins of the western chain. The pebbles of the conglomerates are, for the most part, rounded fragments of the fossiliferous slates before mentioned."

And when describing the effects of granitic injections, he says—

"Professor Sedgwick and Mr. Murchison conceive that this granite (near Brora in Sutherlandshire) has been upheaved in a solid form; and that in breaking through the submarine deposits, with which it was, perhaps, originally in contact, it has fractured them so as to form a breccia along the line of junction.

"It is chiefly in the case of calcareous rocks, that solidification takes place at the time of deposition. But there are many deposits in which a cementing process comes into operation long afterwards. We may sometimes observe, where the water of ferruginous or calcareous springs has flowed through a bed of sand or gravel, that iron or carbonate of lime has been deposited in the interstices

between the grains or pebbles, so that in certain places the whole has been bound into stone, the same set of strata remaining, in other parts, loose and incoherent. Proofs of a similar cementing process are seen in a rock at Kelloway in Wiltshire. . . . . .

"In what manner silex and carbonate of lime may become widely diffused in small quantities through the waters which permeate the earth's crust, will be spoken of presently, but I may remark here, that such waters are always passing in the case of thermal springs, from hotter to colder parts of the interior of the earth, and as often as the temperature of the solvent is lowered, mineral matter has a tendency to separate from it and solidify. Thus a stony cement is often supplied to any sand, pebbles, or fragmentary mixture. In some conglomerates, like the pudding-stone of Hertfordshire, pebbles of flint and grains of sand are united by a siliceous cement so firmly, that if a block be fractured, the rent passes as readily through the pebbles as through the cement."*

Mr. Miller observes, in describing the conglomerate of the old red sandstone—

"The first scene in the *Tempest* opens amid the confusion and turmoil of the hurricane, amid thunders and lightnings, the roar of the wind, the shouts of the seamen, the rattling of the cordage, and the wild dash of the billows. The history of the period represented by the old red sandstone seems, in what now forms the northern half of Scotland, to have opened in a similar manner. The finely laminated lower tilestones of England, were deposited evidently in a calm sea.

"During the contemporary period in our own country, the vast space which now includes Orkney and Lochness, Dingwall and Gamrie, and many a thousand square miles besides, was the scene of a shallow ocean, perplexed by powerful currents, and agitated by waves. A vast stratum of water-rolled pebbles, varying in depth from 100 feet to 100 yards, remains in a thousand different localities, to testify the disturbing agencies of this time of commotion. The hardest masses which the stratum encloses, porphyries of vitreous fracture, that cut glass as readily as flint, and masses of quartz that strike fire quite as profusely from steel, are yet polished and ground down into bullet-like forms, not an angular fragment appearing in

* Elements, vol. i. pp. 7, 38, 101, 365. vol. ii. pp. 148, 357, 370. vol. i. pp. 74—76.

some parts of the mass for yards together. The debris of our harder rocks rolled for centuries in the beds of our more impetuous rivers, or tossed for ages along our more exposed and precipitous sea-shores, could not present less equivocally the marks of violent and prolonged attrition than the pebbles of this bed. And yet it is surely difficult to conceive how the bottom of any sea should have been so violently and so equally agitated for so greatly extended a space as that which intervenes between Mealforvonie in Inverness-shire and Pomona in Orkney in one direction, and between Applecross and Trouphead in another, and for a period so prolonged that the entire area should have come to be covered with a stratum of rolled pebbles of almost every variety of ancient rock, fifteen storys' height in thickness. The very variety of its contents shows that the period must have been prolonged. A sudden flood sweeps away with it the accumulated debris of a range of mountains; but to blend together, in equal mixture, the debris of many such ranges, as well as to grind down their roughnesses and angularities, and fill up the interstices with the sand and gravel produced in the process, must be a work of time. I have examined with much interest, in various localities, the fragments of ancient rock enclosed in this formation. Many of them are no longer to be found *in situ*, and the group is essentially different from that presented by the more modern gravels. The period of this shallow and stormy ocean passed. The bottom, composed of the identical conglomerate which now forms the summits of some of our loftiest mountains, sank throughout its wide area to a depth so profound as to be little affected by tides or tempests. During this second period there took place a vast deposit of coarse sandstone strata, with here and there a few thin beds of rolled pebbles. The general subsidence of the bottom still continued, and after a deposit of full ninety feet had overlain the conglomerate, the depth became still more profound than at first. A fine semi-calcareous, semi-aluminous deposition took place in waters perfectly undisturbed; and here we first find proof that this ancient ocean literally swarmed with life—that its bottom was covered with miniature forests of algæ, and its waters darkened by immense shoals of fish.*

* Old Red Sandstone, pp. 272—275. It is scarcely possible, for even an implicit believer in the Dynamical Theory, more perfectly to describe what would take place after the earth was made to rotate for the first time, and when the ancient waters, at the commencement, rushed towards the equator surcharged with debris, sand, and silt, to complete the figure of equilibrium, and having accomplished this, assumed a death-like stillness, and deposited the

These evidences are so concurrent in themselves, and so conclusive on the whole, in favour of the position which we at present seek to establish, respecting these singular formations, which intervene amongst the others, in almost all tracts of country which appear to have been the theatre of great disturbances, that we need not add any further testimony to prove their existence, in precisely the geological localities where the Dynamical Theory required for its perfection, that they should be found; but we shall take occasion, nevertheless, to say a few words as to the explanations which have, hitherto, been given respecting their origin.

It is, we believe, very generally known, that breccias and conglomerates, have ever been interesting objects of enquiry to geologists, having often been made use of as guides to direct their researches, and to point out the relative antiquities of the masses between which they happen to occur. Unfortunately, however, like many other natural evidences, their true meaning has, sometimes, been misinterpreted! But in what other branch of Science have not mistakes also been made? If the detached fragments, formed by subsequent concretion into breccias, have been construed into undeniable proofs, that the rocky masses from whence they were separated, formed pre-existing mountains and continents which had undergone disintegration by catastrophes supposed to be peculiar to the formation of worlds in their nascent state; surely we ought not too severely to condemn those misinterpretations, occasioned by appearances so specious and apparently so infallible: for it must be remembered that these natural finger-posts, particularly when taken in the abstract, often point in *opposite directions;* and, considering that no one ever before suspected that they owed their origin to the same dynamical causes which simultaneously elevated the continents and mountains of the world; it is by no means surprising, that *the reading* of some should have made converts of others, and among these, of some of the most accomplished geologists of the past and present eras.

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fine particles; while the subsequent evaporation, when the atmosphere was formed, caused the dessication of the very finest, which had, until then, remained.—AUTHOR.

Returning to our subject: the first impression which presents itself to the mind, as beforementioned, is the infinite wisdom which willed them into existence; forming, as they do, the great cementing processes by which the rocky crust of the globe is so admirably bound together, and the heterogeneous materials of its outer crust united into one impervious whole; rough, it is true, to our microscopic eyes, but no doubt preserving the most perfect proportion to its own gigantic dimensions! When we consider that the whole of this wonderful operation, extending, though not continuously, over nearly the whole surface of the globe, was begun and completed within the short space of two natural days, we cannot fail to be impressed with increasing admiration and reverence; while we acquire juster conceptions of the power, and the attributes of the wonder-working God, "who weighed the hills in his balance, and meted out the ocean in the palm of his hand."

These formations, thus wisely and powerfully brought into existence, appear to have had other very important ends to serve. They greatly facilitated the relative movements between the primary amorphous masses and the stratified rocks, and also between the different formations of strata; enabling them to pass each other, in order to assume their places in the elevations they were destined to form, with less evolution of heat than would otherwise have taken place, had the moving masses been composed of fibrous and less brittle materials, resisting disintegration, and supplying no natural rollers to "lighten the heavy load along." For, although the *heat* evolved by those moving masses was absolutely essential for the accomplishment of important mineralogical phenomena, such as the formation of veins, &c., yet numberless means were adopted for confining its effects to the localities where it was most required, and for modifying its application. One of these appears to have been *the creation of the great breccia and conglomerate beds* which we have just been contemplating; another, the interposing of alternate layers of aluminous material (an indifferent conductor of heat) between the primary masses and the calcareous formations; and both aluminous and calcareous strata between the injected rocks and the coal measures, in order to defend the latter from too intense a de-

gree of fusion, during the convulsive movements of a world starting into life; which, otherwise, would have deprived the carboniferous series of those qualifications which now render them so useful.

Meanwhile, it should be remembered, that as the coal measures, when these revolutions were taking place, formed the superior strata of the ancient world, they would naturally be in so soft and flexible a state as would permit of their yielding, in a certain degree, to whatever form was impressed upon them, by the more rigid masses brought violently into contact; their plasticity, at the same time enabling and inducing them to assume the inflexions of the older strata on which they now repose. The evidence for the truth of these assertions are still discoverable by the forms in which the carboniferous concretions, and their associated shales are found in the various workings of the coal mines; while the testimony derived from the perfection and uninjured condition of their fossil vegetable remains, sufficiently evince, that they were not removed far from where they had been formed.

The fact of the coal measures presenting these peculiar features, in a very striking degree, is so abundantly evidenced by what is said of them in every geological treatise, that it will be quite superfluous to arrest the progress of our general argument, by going into details. They have already been frequently alluded to, in the quotations given, and they will, of themselves, come out more prominently in those which we shall have occasion to make as we proceed with our discourse.

It will likewise, hereafter, be made manifest, that with the same provident forethought and infinite wisdom, by which the coal measures were thus shielded *underneath* from the fusing heat of the moving mountain masses, the elevation of these very mountains was made the means of spreading abroad an immense mass of *debris*, which was conveyed by the rushing tumultuous ocean, and deposited upon the upper surface of these carboniferous formations, in order to protect them, alike, from the denuding and transporting influence of that very ocean in its course towards the equatorial regions; from the sudden evaporation that took place when the land was separated from the water; and from the slower, but no less destructive, agency

of the atmosphere that was shortly thereafter to be formed. The more we investigate into the works of creation, the more thoroughly will we be convinced of the wisdom and forethought of the Creator.

By the concluding paragraph of the *eighty-third* Theorem, it will be seen, that another immediate effect of *friction* is, "*heat, independently of fire or flame;*" *and, consequently, that the degree of heat is in proportion to the friction.*

As friction—according to the evidences connected with the same Theorem—depends on the amount of the pressure, together with the roughness of the surfaces brought into contact, it follows, *that the amount which would necessarily be evolved by the movement of the continents and mountain chains, must have been almost infinite*, judging by our ideas of friction proceeding from mechanical causes; while the heat must have arisen to a corresponding degree of intensity—a fact which will appear more evident when we take into account the combustible nature of the mineral materials of which these mountain masses are composed.*

It is, likewise, to be considered that, as the degree of friction, and, consequently, of heat, depend on the amount of *motion*, the rocky masses would be subjected to both of these results in direct proportion as they became the central and more elevated portions of mountain chains, inasmuch as these had to traverse greater distances before they reached their eminences. Compounding these together, we have, as a common result, *that the symptoms of fusion should most strongly pervade the neighbourhood of the greatest and most elevated masses, which have been forcibly intruded among the associated strata.*

This is precisely what the researches of geologists reveal to us has taken place; for by the *twentieth* Theorem it will be perceived, "*That considering the granitic, trappean, serpentinous and other rocks of similar origin to have been injected amongst the stratified masses; and that evidence still remains of great heat having been present when and where these protrusions took place—shown as well by the structure of the igneous injections themselves as by the fused, altered, rent*

* See Theorems, 98, 99 103.

condition, and slaty cleavage of the rocks contiguous to them— it is, likewise, considered that the extent of the alteration, and the insensible transition of the altered mass, are in direct proportion to the volume of that which has been injected."

The following are some of the evidences which declare, in the most striking manner, the effects produced by *fusion* among the mineral masses; and which, we think, are capable of being traced to their source, by a train of causes and effects which link the fusion of the injected rocks to heat, occasioned by the friction which necessarily attended the operations of the Creator, on the first day of the Mosaic week.

"The peculiar condition of the rocks," says Professor Buckland, "which form the side walls of granitic veins and basaltic dykes, affords another argument in favour of their igneous origin; thus, wherever the early slate rocks are intersected by granitic veins, they are usually altered to a state approximating to that of fine-grained mica slate, or hornblende slate. The secondary and tertiary rocks, also, when they are intersected by basaltic dykes, have frequently undergone some change; beds of shale and sandstone are indurated and reduced to jaspar; compact limestone and chalk are converted to crystalline marble, and chalk flints altered to a state like that resulting from heat in an artificial furnace."*

M. de la Beche, in his Manual, thus expresses himself with respect to the *unstratified rocks*:—

"The rocks constituting this natural group are widely distributed over the surface of the world, are found mixed with almost all the stratified rocks, and bear every mark of having been ejected from beneath. They commonly occur either as protruded masses, as overlapping masses resulting from the spread of matter after ejection, or as veinstones filling fissures, apparently consequent on some violence to which the strata have been subjected. . . . .

"Such are the rocks" (he continues after having given a minute description of each) "commonly considered unstratified. It will have been seen, that they so pass into one another that distinctions are not easily established between them. Mineralogical granite

* Bridgewater Treatise, vol. ii. p. 9.

passes through various stages, and graduates into the compounds named greenstone, and others of the trappean class.

"Thus far we have only seen granite rising through and covering other rocks in considerable masses, but we have also evidence in granite veins, that the matter of the rock was in such a state of igneous fusion, as to penetrate into thin clefts opened in stratified and older rocks by some violence, such as probably resulted from the upburst of the igneous matter accompanied by elastic vapours, ... the intruding substance breaking off and including in it all loose fragments, and those projecting portions which opposed the fury of the injection.

"According to Mr. Aikin, a good example of the apparent interstratification of greenstone with the coal measures is observable at *Birch Hill Colliery*, Staffordshire. The bed seems to be connected with a mass of trap on one side, whence it has been injected amongst the strata, altering the coal where it covers it by depriving it of its bitumen.

"There is a trap dyke described by Mr. Hill, as occurring at *Walker Colliery*, Newcastle, which has converted the coal contiguous to it into coke.

"The annexed figure will illustrate a considerable fracture and alteration in the limestones at the *Black Head*, *Babbacombe Bay*, Devon, effected by the eruption of greenstone. . . . . The slates and limestones have evidently suffered, not only from the mechanical action of the erupted greenstone, but also chemically from the proximity of the mass in a state of igneous fusion.

"Mr. Lyell has described a serpentine dyke which cuts through a sandstone near West Balloch farm, in Forfarshire. . . . . . The serpentine is also said to be bounded on the left bank of the *Carity* 'by a vertical mass of sandstone conglomerate evidently much altered, some parts approaching to jaspar in hardness and appearance,' in which some of the quartz pebbles have even been fractured and reunited. This fracture of the quartz pebbles is precisely what we should expect from a sudden application of heat, and would speak strongly in favour of the once igneous fusion of the serpentine in the dyke, if any evidence were wanting.

"When we recollect that the intrusion of igneous rocks has been sufficent to convert chalk into granular limestone, in the North of Ireland, we need not be surprised that other rocks have been altered by the intrusion of similar substances. The slates, for instance, in many parts of the country surrounding the granite of Dartmoor, Devon, have suf-

fered from its intrusion. . . . . These changes are no more than we should expect from the intrusion of a mass in a state of igneous fusion. . . . . Indeed, cases of induration and alteration of rocks in contact with igneous products are so common, that it would be useless further to enumerate them."*

"We have now," says Mr. Lyell "to examine those crystalline (or hypogene) strata to which the name of *metamorphic* has been assigned. This last term expresses a theoretical opinion that such strata, after having been deposited from water, acquired by the influences of heat and other causes a highly crystalline texture. . . . . Having said thus much of the mineral composition of the metamorphic rocks, I may combine what remains to be said of their structure and history with an account of the opinions entertained of their probable origin.

In consequence, somewhat farther on, he continues—

"It has been seen, that geologists have been very generally led to infer, from the phenomena of joints and slaty cleavage, that mountain masses, of which the sedimentary origin is unquestionable, have been acted upon simultaneously by vast crystalline forces. That the structure of fossiliferous strata has often been modified by some general cause since their original deposition, and even subsequently to their consolidation and dislocation, is undeniable. These facts prepare us to believe that still greater changes may have been worked out by a greater intensity, or more prolonged development of the same agency, combined, perhaps, with other causes. Now we have seen that near the contact of granitic veins and volcanic dykes, very extraordinary alterations in rocks have taken place, more especially in the neighbourhood of granite. . . . . The stratified rocks (Fiord of Christiana, Norway), replete with shells and zoophytes, consist chiefly of shale, limestone, and some sandstone, and all these are invariably altered near the granite for a distance of from 50 to 400 yards. The aluminous shales are hardened and have become flinty. Ribboned jaspar is produced by the hardening of alternate layers of green and chocolate coloured schists. . . . . In some places the siliceous matter of the schist becomes a granular quartz, and when hornblende and mica are added, the altered rock loses its stratification and passes into a kind of granite. The limestone, which at points remote from the granite is of an earthy texture,

* Pages 486—510.

blue colour, and often abounds in corals, becomes a white granular marble near the granite, sometimes siliceous, the granular structure extending occasionally upwards of 400 yards from the junction; and the corals being for the most part obliterated, though sometimes preserved even in the white marble. . . . . .

"Now, the alterations above described as superinduced in rocks by volcanic dykes and granite veins prove incontestably that powers exist in nature capable of transforming fossiliferous into crystalline strata—powers capable of generating in them a new mineral character, similar, nay, often absolutely identical, with that of gneiss, mica-schist and other stratified members of the hypogene series. . . . . . Although the precise nature of these altering causes is obscure, we must suppose the influence of heat to be in some way connected with the transmutation, if, for reasons before explained, we concede the igneous origin of granite. . . . . .

"We may easily suppose, therefore, as exemplified by the experiments of Gregory Watt, that all traces of shells and other organic remains may be destroyed, and that new chemical combinations may arise, without the mass being so fused as that the lines of stratification should be wholly obliterated."

In conclusion from this intelligent and instructive geologist:

"I shall mention," says he, "one or two examples of alteration on a grand scale, in order to explain the kind of reasoning by which we are led to infer that dense masses of fossiliferous strata have been converted into crystalline rock.

"*Northern Apennines.—Carrara.*—The celebrated marble of Carrara, used in sculpture, was once regarded as a type of primitive limestone. It abounds in the mountains of Massa Carrara, or the 'Apnan Alps,' as they have been called, the highest peaks of which are nearly 6,000 feet high. Its great antiquity was inferred from its mineral texture, from the absence of fossils, and its passage downwards into talc-schist and garnetiferous mica-schist; these rocks again graduating downwards into gneiss, which is penetrated at Forno, by granite veins. Now, the researches of MM. Savi, Boué, Pareto, Guidoni, De la Beche, and especially Hoffmann, have demonstrated that this marble, once supposed to be formed before the existence of organic beings, is, in fact, an altered limestone of the oolitic period, and the underlying crystalline schists are secondary sandstones and shales, modified by plutonic action.

"*Alps of Switzerland.*—In the Alps, analogous conclusions have been drawn respecting the alteration of strata on a still more extended scale. In the eastern part of that chain, some of the primary fossiliferous strata, as well as the older secondary formations, together with the oolitic and cretaceous rocks, are distinctly recognizable. Tertiary deposits also appear in a less elevated position on the flanks of the Eastern Alps; but in the Central or Swiss Alps, the primary fossiliferous and older secondary formations disappear, and the cretaceous, oolitic, and liassic strata graduate insensibly into metamorphic rocks, consisting of granular limestone, talc-schist, talcose-gneiss, micaceous-schist, and other varieties."*

"The centre or axis," says Professor Phillips, "of mountain groups, and consequently of the disturbing movement (during its upheaval), is generally *seen* to be a mass of *unstratified rock*, such as granite, seinite, &c., which shows, by a variety of circumstances, that it was not deposited in water, but rather crystallized from igneous fusion. Very often, indeed generally, proofs of its having been in a state of fusion at the time of the elevation of the strata, are found in the extension of veins of the crystallized into the sedimentary rocks, accompanied by the characteristic effects of heat.

"We are thus led to associate the phenomena of the disturbance of strata, with the eruption of the crystallized rock from beneath; and though the latter is indeed not exactly the cause of the former, but rather a concomitant effect of some general dynamical agency, geologists are not greatly to be censured who describe the phenomena as they appear, and speak of the disturbed positions of the strata, as *effects* of the elevation of unstratified rocks.

"What, then, is the fruit of all this discussion? It is the conviction that the gneiss, mica-slate, primary limestone, quartz rock, &c., are stratified rocks; the most important evidence being the alternation of these different rocks, and the lamination of different substances in them, but that the causes which tend among all rocks to complicate the stratification with new structures, have gone to the maximum in these the oldest of all; the principal of these causes being heat, either locally exhibited in the neighbourhood of igneous crystallized rocks, or generally pervading the whole mass of deposits."†

These quotations are sufficient to convince any one, that

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* Lyell's Elements of Geology, vol. ii. pp. 379, 386, 401, 403—407, 419, 421.
† Treatise, pp. 61, 75.

when geologists have occasion to reason respecting the symptoms of fusion among the older rocks, they never doubt its existence in the *intruded masses;* these are, at once, assumed as having been injected, while yet liquid by igneous fusion; and the whole of their reasoning is directed to exhibit the effects on the masses which are found in their immediate vicinity, while the fact of the injected mass itself having been fused is never even doubted. This, of course, is an important concession in favour of the views we have adopted; and it remains only for us to be able to prove *the source of the heat, whose existence is thus so unanimously and unhesitatingly admitted.*

These symptoms of heat are, generally, found to exist in a ratio proportioned to the *friction* supposed to have been experienced;* that is, in proportion to the mass of matter moved out of perfect horizontality, the distance it had to go, and the asperities overcome in moving from horizontality into the present posture.

The views adopted by this theory lead to the conclusion, *That as the heat which fused the primary rocks proceeded entirely from friction, engendered by motion acting on their combustible materials, it must have reached its maximum in the interior of elevations, where the motion was likewise greatest.*

In confirmation of this doctrine, which is peculiar to the Dynamical Theory, we have merely to take up and substantiate the concluding paragraph of the *twentieth* Theorem, namely: "*That the extent of the alteration and the insensible tran-*

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* We are particularly desirous it should be understood, that while the heat here treated of has no connection whatever with the *warmth* existing in the primitive world, neither did it, in any manner, proceed *directly* from the action of the first rays of light; for, had it done so, it would not only have acted *equally over all the surface* of the earth, but *would have affected the surface more than the internal rocky masses,* a tendency precisely the reverse of what appears to have been designed during the great revolution now under consideration. For, had it been so produced, before it could have effected the fusion of rocks forming the interior of mountains and elevations, in order to produce their veins, ramifications, and other attendant circumstances, it must have first passed *through,* and consequently, to a certain extent, *destroyed the whole* of the *calcareous* and *carboniferous* formations which surround and overlie the primary, a result expressly sought to be avoided, and arranged for accordingly.—AUTHOR.

sition of the altered mass, are in direct proportion to the volume of that which has been injected." Applying this to the primary strata, and transition series, it will satisfactorily account for the prevalence of the crystalline texture in both of these formations; for, if the heat which proceeded from a trap, or a greenstone dyke has been, in numberless instances, sufficient to alter the texture, to a certain extent, of the strata in their immediate vicinity, to what extent must these fierce heats have penetrated, which radiated from the fused granitic nucleii of entire mountain ranges? In considering this we must remember, that the intensity of "the radiation of heat is in direct proportion to the magnitude of the radiating surface."*

It is presumed, that what has been adduced will serve to explain what has hitherto been an embarrassing point in geology, namely; the prevalence of crystalline stratiform rocks among the primary and transition series. For instance—Marble is known to be carbonate of lime, fused under great heat and a corresponding pressure; and which, together with other rocks under similar circumstances, have all along demanded the supposition of the presence and action of greater heats than could be admitted to have been general, when the character and texture of other strata, somewhat removed from these foci of fusion, were taken into consideration.

While viewing the subject in the light we have placed it, this difficulty vanishes at once; and the *altered* and *crystalline* textures of the older strata are recognised to be quite in accordance with the other prominent feature in their character, viz., deposition from aqueous solution—for by this it is seen, that the same cause which raised them from the horizontal position in which they were formed, has likewise fused, crystallized, and reconsolidated them.

Indeed, we are much disposed to consider all rocks to have been originally stratiform: and were it essential for the elucidation of our theory, we might delay the general argument while we brought forward the evidences in favour of this assumption. But how such mineral masses as the granitic, trappean, basaltic rocks, and such like, from having been strati-

* Evidences in connection with the 57th Theorem.

form, assumed their present amorphous texture and "unshapeliness," unless it were from the effects of the heat engendered by the earth's protorotation, we cannot, with our present knowledge, undertake to explain.

Having so recently had occasion to adduce evidences confirmatory of the *fused* and *altered* condition of the formations which are found contiguous to intruded amorphous masses—a branch of this same argument—we shall, on this occasion, restrict the proofs to such as show the prevailing *geological sites* of these *altered rocks*, and the accordance of their character and features in general, with our previous assumptions.

Scarcely any passage can be more conclusive than the one we have already given repeatedly from Professor Phillips's work, wherein he shows the immediate connection between the disturbed state of the strata and the eruption of unstratified rocks. When treating of slaty cleavage planes and *symmetrical joints*, and contrasting them with *stratified structure*, he goes on to say—

"They are, in fact, superposed structures, and from what is known of the introduction of similar structures into ordinary clays and shales, by the side and in the vicinity of igneous rocks, independent of general considerations, such as the high degree of induration of these rocks, there is little doubt that the agency of heat is the general cause of these phenomena of structure."

And again—

"What then is the fruit of all this discussion? It is the conviction that the gneiss, mica-slate, primary limestone, quartz rock, &c., are stratified rocks; . . . . . but that the causes which tend among all rocks to complicate the stratification with new structures, have gone to the maximum in these the oldest of all; the principal of these causes being heat, either locally exhibited in the neighbourhood of igneous crystallized rocks, or generally pervading the whole mass of deposits."*

Mr. Miller bears testimony to the same effect, by the description he gives of the elevation of mountains.

* Pages 82, 83, 75.

"In most of our hills," he observes, "the upheaving agency has been actively at work, and the space within is occupied by an immense nucleus of inferior rock, around which the upper formation is wrapped like a caul, just as the vegetable mould or diluvium wraps up this superior covering in turn.

"One of our best known Scottish mountains—the gigantic Ben Nevis—furnishes an admirable illustration of this latter construction of hill. It is composed of three zones or rings of rock, the one rising over and out of the other, like the cases of an opera glass drawn out. The lower zone is composed of gneiss and mica-slate—the middle zone of granite—the terminating zone of porphyry. The elevating power appears to have acted in the centre, as in the well-known case of Jorullo, in the neighbourhood of the City of Mexico, where a level tract, four square miles in extent, rose about the middle of the last century, into a high dome of more than double the height of Arthur's Seat. In the formation of our Scottish mountain, the gneiss and mica-slate of the district seem to have been upheaved, during the first period of plutonic action in the locality, into a rounded hill of moderate altitude, but of huge base. The upheaving power continued to operate—the gneiss and mica-slate gave way at top—and out of this lower dome there arose a higher dome of granite, which in an after and terminating period of the internal activity, gave way in turn to yet a third and last dome of porphyry. Now, had the elevating forces ceased to operate just ere the gneiss and mica-slate had given way, we would have known nothing of the interior nucleus of granite—had they ceased just ere the granite had given way, we would have known nothing of the yet deeper nucleus of porphyry; and yet the granite and the porphyry would assuredly have been there. Nor could any application of the measuring rule to the side of the hill have ascertained the thickness of its outer covering—the gneiss and the mica-schist."*

Mr. Lyell says—

"Although strata in the neigbourhood of dykes are thus altered in a variety of cases, shale being turned into flinty slate or jasper, limestone into crystalline marble, sandstone into quartz, coal into coke, and the fossil remains of all such strata wholly or in part

* Old Red Sandstone, pp. 58—60.

obliterated, it is by no means uncommon to meet with the same rocks, even in the same districts, absolutely unchanged in the proximity of volcanic dykes."

Again—

"In proof of the mechanical force which the fluid trap has sometimes exerted on the rocks into which it has intruded itself, I may refer to the Whin-sill, where a mass of basalt, from 60 to 80 feet in height, is in part wedged in between the rocks of limestone and shale, with which they were united. . . . . .

"When trap dykes were described in the preceding chapter, they were shown to be more modern than all the strata which they traverse. . . . . .

"When plutonic rocks send veins into strata, and alter them near the point of contact, in the manner we have before described, it is clear that, like intrusive traps which have been separated from the great mass of limestone and shale, they are newer than the strata which they invade and alter.

"We have seen that, near the immediate contact of granitic veins and volcanic dykes, very extraordinary alteration in rocks have taken place, more especially in the neighbourhood of granite. We learn from the investigations of M. Dupenoy that in the Eastern Pyrenees there are mountain masses of granite posterior in date to the formations called lias and chalk of that district, and that these latter fossiliferous rocks are greatly altered in texture, and often charged with iron ore, in the neighbourhood of the granite."

And finally, from this geologist—

"In considering, then"—he says—"the various data already enumerated, the forms of stratification in metamorphic rocks, their passage on the one hand into the fossiliferous, and on the other into the plutonic formations, and the conversions which can be ascertained to have occurred in the vicinity of granite, we may conclude, that gneiss and mica-schist may be nothing more than altered micaceous and argillaceous sandstones, that granular quartz may have been derived from siliceous sandstone, and compact quartz from the same materials. Clay-slate may be altered shale, and granular marble may have originated in the form of ordinary limestone, replete with shells and corals, which have since been obliterated;

and, lastly, calcareous sands and marls may have been changed into impure crystalline limestone. 'Hornblende-schist, says Dr. M'Culloch, may at first have been mere clay.' And, 'the anthracite found associated with hypogene rocks may have been coal, for we know that, in the vicinity of some trap dykes, coal is converted into anthracite'."*

* Elements of Geology, vol. ii. pp. 224—226, 241, 350, 401—405, 412, 413.

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXI.

Evidences of the existence in former times of fusion in the primary rocks, derived from their *internal* or *mineralogical* structure. Carbonate of lime fused under pressure—mineralogical results. Crystallization proceeding from igneous fusion. Geological evidences to prove that a considerable proportion of the rocky crust of the Earth is crystalline in its texture. Essential difference between rocks, properly called crystalline, of older formation, and those resulting from modern volcanoes, called lavas.

Having thus established the presence formerly of fusion amongst the primary stratified and unstratified rocks, and the stratifications of the secondary series, by tracing its consequences to those formations which are in contact with them, and which, for the sake of perspicuity, may be called *the external evidences of that intense heat;* we must next endeavour to bring home the same degree of evidence to the more intimate structure of those rocks, by enquiring whether in their *mineralogical* character, and other *internal* circumstances, they afford corresponding marks of having been subjected to that fierce heat, and consequent fusion, which are recognisable, externally, at their junction with other rocks.

To do this properly, however, we must depart for a moment from the straight line of our argument, to direct the attention to some of the phenomena which usually accompany the liquifaction of mineral masses by heat. These are—*First.* The results which proceed from heating mineral masses under pressure, and permitting them to cool slowly, or by excluding them from the action of atmospheric air; and *secondly*. Crys-

tallization from igneous liquifaction. These subjects will occupy our attention in the order in which they stand.

The *hundred and first* Theorem states, "*That by experiment* it has been proved, that if carbonate of lime be heated under a pressure equal to* 1,700 *feet of sea water; or to a column of liquid lava* 600 *feet high, so as to prevent the escape of its carbonic acid, it may be melted at a temperature even not higher than* 22° *of Wedgewood's scale. That by this process it acquires considerable hardness and closeness of texture, approaching, in these qualities, as well as in fracture and specific gravity, to the finer kind of limestone or marble. And latterly it has been discovered, that even without compression, carbonate of lime may be fused by the sudden application of violent heat, or by submitting it to heat in a large mass.*"

The following succinct details of the scientific and interesting experiments on which this Theorem is founded, may be agreeable to some of our readers; and being, by their character, quite conclusive, will close the argument for this particular point:—

"The alterations of limestone in contact with trappean rocks is sufficiently common, producing a greater or less amount of crystallization, in accordance with the well-known experiments of Sir James Hall (*Transactions of the Royal Society of Edinburgh, vol.* vi.), who has proved, that when carbonate of lime is subjected to great heat beneath sufficient pressure, it does not part with its carbonic acid, but that it is fused and is rendered crystalline—a fact previously doubted."†

Mr. Lyell says—

"These phenomena" (manifested by the volcanic rocks of the post-pliocene period) "are in perfect harmony with the results of the experiments of Sir James Hall and Mr. Gregory Watt, which have shown that a glassy texture is the effect of sudden cooling, and that, on the contrary, a crystalline grain is produced where fused minerals are allowed to consolidate slowly and tranquilly under high pressure."

* By Sir James Hall.

† Manual of Geology, by H. T. de la Beche, p. 497.

And again—

"The experiments of Gregory Watt, in fusing rocks in the laboratory, and allowing them to consolidate by slow cooling, prove distinctly that a rock need not be perfectly melted in order that a re-arrangement of its component particles should take place, and a partial crystallization ensue. We may, therefore, easily suppose, that all traces of shells and other organic remains may be destroyed; and that new chemical combinations may arise, without the mass being so fused, as that the lines of stratification should be wholly obliterated."*

This celebrated experiment has been interwoven by Sir John Herschel so admirably into the evidences brought forward by him in favour of the Copernican system, that we cannot resist giving the passage in his own language. When showing the remarkable confirmation which that system of the celestial mechanism received, by the subsequent discovery of the crescent form which Venus assumes in certain parts of her orbit around the sun, he goes on to say—

"The history of science affords, perhaps, only one instance analogous to this, namely, when Dr. Hutton expounded his theory of the consolidation of rocks by the application of heat, at a great depth below the bed of the ocean, and especially of that of marble by actual fusion; it was objected that, whatever might be the case with others, with calcareous or marble rocks, at least, it was impossible to grant such a cause of consolidation, since heat decomposes their substance and converts it into quick lime, by driving off the carbonic acid, and leaving a substance perfectly infusible. To this he replied, that the pressure under which the heat was applied would prevent the escape of the carbonic acid, and, that being retained, it might be expected to give that fusibility to the compound which the simple quicklime wanted. The next generation saw this anticipation converted into an observed fact, and verified by the direct experiments of Sir James Hall, who actually succeeded in melting marble, by retaining its carbonic acid under violent pressure."†

With regard to *crystallization by fusion*, which seems to

* Elements, vol. ii. pp. 259, 406.

† Discourse on Natural Philosophy, Cab. Cyc. pp. 269, 270.

have acted so important a part in the ultimate mineralogical composition of the primary and other secondary formations, we bring forward, in succession, the two following Theorems which have relation to it. We more especially direct the attention to the last.

The *hundred and eleventh* Theorem states, "*That when substances are rendered fluid, with perfect mobility amongst their particles, either by igneous fusion or by solution, and are suffered to pass with adequate slowness into the solid state, the attractive forces—called homogenous attraction—frequently re-arrange these particles into regular polyhedral figures or geometrical solids; to which the name of* CRYSTALS *has been given. That mere approximation of the particles is not, however, alone sufficient to produce crystallization, they must also change the direction of their poles from the fluid colocation to their position in the solid state, which may be effected by the following means, namely,* 1. *By vibratory motion communicated either from the atmosphere or any other moving body.* 2. *By contact of any part of the fluid with a point of a solid of similar composition previously formed, or other substance.* 3. *By the slow and continued agency of voltaic electricity operating in water. That darkness, in most instances, favours crystallization. That heat, likewise, exercises considerable influence on these phenomena; and, lastly, that the same substance, in crystallizing, not unfrequently assumes a diversity of forms; though, in general, the same substance, under similar circumstances, assumes the same form.*"

In continuation of the same subject, the *hundred and twelfth* Theorem says—"*That most of the rocks which compose the mineral crust of the earth are in a crystallized state. Granite, for example, consisting of crystals of quartz, felspar, and mica; marble of crystals of carbonate of lime, &c. And that the whole phenomena attendant on crystallization go to prove that substances having the same crystalline form must consist of ultimate atoms, having the same figure, and arranged in the same order, so that the form of crystals is dependant on their atomic constitution.*"

We subjoin some of the evidences which substantiate those

parts of the above Theorems which relate to our present enquiry:—

"It cannot be supposed," says Sir John Herschel, "that these and other tangible qualities, as they may be called, should subsist in solids without a corresponding mechanism in their internal structure. That they have such a mechanism, and *that* a very curious and intricate one, the phenomena of crystallography sufficiently show.

"This interesting and beautiful department of natural science is of comparatively very modern date. That many natural substances affected certain forms must have been known from the earliest times. But till the time of Linnæus no material attention seems to have been bestowed upon the subject. . . . . .

"Bergmann, who followed this great master and also Romé de Lisle, reasoning on a fact imparted to him by one of his pupils, showed how, at least, one species of crystal might be built up of thin laminæ ranged in a certain order and following certain rules of superposition. He failed, however, in deducing just and general conclusions from this remark, which, correctly viewed, is the foundation of the most important law of crystallography, *that which connects the primitive form with other forms capable of being exhibited by the same substance, by a certain fixed relation*. . . . . .

But "whatever conception we may form of the manner in which the particles of a crystal cohere and form masses, it is next to impossible to divest ourselves of the idea of a determinate figure common to them all. Any other supposition, indeed, would be incompatible with that exact similarity in all other respects which the phenomena of chemistry may be considered as having demonstrated. . . . . .

"That peculiar internal constitution of solid bodies, whatever it be, which is indicated by the assumption of determinate figures, &c., cannot but have an important influence on all their relations to external agents, and accordingly the division of bodies into crystallized and uncrystallized, or imperfectly crystallized, is one of the most universal importance. . . . . . Indeed, there can be little doubt that modifications similarly depending on the internal structure of crystals, will be traced through every department of physics. . . . .

"From what has been said, it is clear, that if we look upon solid bodies as collections of particles or atoms, held together and kept

in their places by the perpetual action of attractive and repulsive forces, we cannot suppose these forces, at least in crystallized substances, to act alike in all directions. Hence arises the conception of *polarity*, of which we see an instance, on a great scale, in the magnetic needle, but which, under modified forms, there is nothing to prevent us from conceiving to act among the ultimate atoms of solid or even fluid bodies, and to produce all the phenomena which they exhibit in their crystallized state, either when acting on each other, or on light, heat, &c. . . . . .

"The mutual attractions and repulsions of the particles of matter, then, and their polarity, whether regarded as an original or a derivative property, are the forces which, acting with great energy, and within very confined limits, we must look to as the principles on which the intimate constitution of all bodies and many of their mutual actions depend.

"These are what are understood by the general term of *molecular forces*. Molecular attraction has been attempted to be confounded, by some, with the general *attraction of gravity*, which all matter exerts on all other matter, but this idea is refuted by the plainest facts."*

"Heat appears," observes Mrs. Somerville, "to have a great influence on the phenomena of crystallization, not only when the particles of matter are free, but even when firmly united, for it dissolves their union and gives them another determination. . . . . .

"All attendant circumstances go to prove, that substances having the same crystalline form must consist of ultimate atoms, having the same figure, and arranged in the very same order; so that the form of crystals is dependant on their atomic constitution. . . . . .

"*Hence it may be inferred, that all substances are composed of atoms, on whose magnitude, density, and form their nature and qualities depend; and as these qualities are unchangeable the ultimate particles of matter must be incapable of wear—the same now as when created.*†

"Crystals formed rapidly are generally imperfect and soft; and M. Becquerel found that seven years of constant voltaic action were necessary for the crystallization of some of the hard substances. If this law be general, how many ages may be required for the formation of a diamond!‡

"Not only do we find"—says the writer on heat in the Cabinet

* Discourse on Natural Philosophy, Cab. Cyc. pp. 239—245.

† 56th Theorem. ‡ Connexion of the Sciences, pp. 125, 127, 312.

Cyclopædia—"proofs that bodies consist of infinitely minute molecules, but we also discover in the effects of crystallization, clear evidence that such molecules in different bodies have different shapes, which shapes are plainly indicated to us by the effects of crystallization, although the particles which effect such forms be so infinitely minute as to elude all means of direct observation, even with the aid which the powers of science can afford to the senses.

"Bodies composed of such particles are found to exist in a great variety of states. . . . . . To account for these effects, we must suppose a class of physical agents acting on the component molecules of bodies analogous to those influences with which astronomy and mechanics make us acquainted, and which act on larger masses. By the force of gravitation the masses of the planets and satellites have a tendency to approach each other with definite forces. Electricity and magnetism, in their effects, afford examples of force, both attractive and expansive, exerted by bodies of sensible magnitude one upon another. Analogy, therefore, leads us to expect agents of a similar nature to be exerted between the molecules of bodies, and thus discovers the harmony which reigns among the causes which maintain together the systems of the universe, and those which give coherence and form to the smaller bodies of which those systems are composed."*

In continuation of these scientific evidences, we have to adduce others to the effect, that what thus takes place in the chemical laboratory has prevailed for ages in the great laboratory of nature, and has produced those vast mineral masses which constitute the outer crust of the earth.

Professor Phillips, in a general way, speaks of the unstratified rocks forming "a universal *crystalline* basis to the stratified rocks," and again, "the stratified rocks which are the products of water rest universally on unstratified crystalline rocks, which, through whatever previous conditions their particles may have passed, have assumed their present characters from the agency of heat."

A little farther on he adds—

"The *calcareous* portions are somewhat remarkable among lime-

* Cab. Cyc. vol. 39, pp. 186, 187.

stones for their generally crystalline character. Even the fossiliferous rocks have much of this feature, and all the older beds are really crystallized.

"The case of limestone is soon settled. It is known, that, in contact with igneous rocks, the chalk of Ireland and the limestone of Teesdale, are turned to crystallized carbonate of lime; and experiments in the laboratory have left no doubt of the propriety of referring this crystallization of the limestone to the mere agency of *heat and pressure.* This high temperature must have pervaded, of course, all the rocks with which the altered limestone is associated. But it occurs with nearly all members of the mica-slate and gneiss systems. All these rocks, then, have suffered the influence of heat. In like manner, experimental proof has been offered by the chemist that quartz-rock is merely sandstone altered by heat; and thus we find reason to believe that some of the characters by which gneiss and mica-slate approach to granite, are owing to their having experienced considerable influence of heat."

And in conclusion from this geologist, we give the following summary, adduced by him when referring to some late theories, which endeavour to account for the *transformation into crystalline* material of so great a proportion of the earth's crust:—

"Hence"—says he—"as a consequence, we infer the consolidation and many other characters of primary strata, to be the effect of heat; but this falls short of the proof required, which must be to the extent of showing, not the changes of secondary to primary strata, but the changes of these into granite, and other crystalline rocks generally. Satisfactory proof of this nature and to this extent, is, we believe, nowhere afforded."*

The crystalline structure of the igneous rocks is so well known and admitted by all; and the assumption of a transformation having taken place in producing that texture is so general and implicit, that we need hardly multiply proofs on the subject; we shall, therefore, conclude with a brief observation from Mr. Lyell: which we do the more readily, not only because he has dedicated so much attention to this parti-

* Treatise on Geology, pp. 69, 70, 75, 76, 259.

cular branch of geology, but in this instance he identifies his own opinion—the result of his labours—with that of another distinguished writer.

"Sir John Herschel," says he, in allusion to slaty cleavage, "has suggested, that if rocks have been so heated as to allow a commencement of crystallization; that is to say, if they have been heated to a point at which the particles can begin to move amongst themselves, or at least on their own axes, some general law must then determine the position in which these particles will rest on cooling. Probably that position will have some relation to the direction in which the heat escapes. Now, when all, or a majority of particles of the same nature have a general tendency to one position, that must, of course, determine a cleavage plane. Thus we see the infinitissimal crystals of fresh precipitated sulphate of barytes, and some other such bodies, arrange themselves alike in a fluid in which they float; . . . . . and what occurs in our experiments on a minute scale, may occur in nature on a great one."*

We come now to apply the information which we have acquired to the more direct chain of the general argument, with a view to discover whether the mineralogical structure of the older rocks affords those *internal* symptoms of having been subjected to the fusing heats which this Theory pre-supposes. We find it stated in the *twenty-fourth* Theorem, "*That there exists an essential mineralogical difference between the older crystalline rocks, such as granite, trap, porphyry, serpentine, and others of that age and denomination, considered to be of igneous origin, and those which have been ejected from modern volcanoes, distinguished by the name of lavas, a difference attributed to the greater pressure under which the older masses were formed, to the non-action of the atmosphere and consequent retention of their gaseous or volatile parts, and to the more gradual manner in which they have cooled down.*"

This being an important point, which requires to be well authenticated, we shall go into its evidences somewhat in detail.

* Elements, vol. ii. pp. 399, 400, taken from a letter from the Cape of Good Hope, of 20th February, 1836.

M. de la Beche enters on the subject at once, but with his characteristic caution, when he says—

"If this opinion, of the greater prevalence of the granitic rocks over the trappean at the earliest periods be correct, it would seem to point to a certain condition of things at such periods, which subsequently became so modified that the igneous eruptions became altered. What that condition of things may have been, we do not as yet appear to have any very definite ideas; and we obtain little help on the subject from the phenomena of modern volcanoes, granite never having been known to flow from them. We, however, learn from this circumstance, that igneous eruptions into the atmosphere are not favourable to the production of granites, and we may consequently infer, that the conditions under which granite was produced were not similar to those which we now observe on the surface of the earth; at least so far as relates to those phenomena which occur in the atmosphere. What igneous matter ejected beneath a great pressure of sea may form we are unable to determine, but that it would be greatly modified by such pressure cannot be doubted. . . . . .

"It has been, indeed, generally considered that the mineralogical character of igneous rocks has been changed during the deposit of the stratified rocks, through which they have more or less forced their way; that is, we do not find granite and serpentine flowing from *modern* volcanoes, nor trachite, nor leucitic lavas intimately associated with the oldest strata in such a manner, that their relative differences of age could not be very considerable. . . . . We are compelled, therefore, to admit, that the conditions under which the two kinds of igneous rocks have been formed have not been the same. What these conditions may have been is a separate question, and one, as observed above, requiring investigation; but it will be at once obvious, that the ejection of a mass, in a state of igneous fusion, into the atmosphere, would be likely to have its constituent parts arranged differently from those in a similar manner forced out beneath great pressure, such as we may consider to exist beneath deep seas. Independently, however, of this consideration, there appears to have been something in the condition of the world at the earliest times, causing certain compounds to be formed in great abundance, which does not now continue in such force as to permit the production of similar compounds."*

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* Manual, pp. 493, 501.

"If," says Mr. Lyell, "we examine a large portion of a continent, especially if it contains within it a lofty mountain range, we rarely fail to discover two other classes of rocks, very distinct from either of those above alluded to, and which we can neither assimilate to deposits such as are now accumulated in lakes or seas, nor to those generated *by ordinary volcanic action.* The members of both these divisions of rocks agree in being *highly crystalline* and destitute of organic remains. The rocks of one division have been called *plutonic*, comprehending all the granites and certain porphyries, which are nearly allied in some of their characters to volcanic formations.

"The members of the other class are stratified and often slaty, and have been called by some the *crystalline schists*, in which groups are included gneiss, micaceous-schist, or (mica-slate), hornblende-schist, statuary marble, the finer kinds of roofing slate, and other rocks afterwards to be described. As it is admitted that nothing strictly analogous to these crystalline productions are now to be seen in the progress of formation upon the earth's surface, it will naturally be asked, on what data can we class them as to origin."

And again—

"To a certain extent, however, there is a real distinction between the trappean formations and those to which the term volcanic is almost exclusively confined. The trappean rocks first studied in the North of Germany, and in Norway, France, Scotland, and other countries, were either such as had been formed entirely under deep water, or had been injected into fissures and intruded between strata, and which had never flowed out in the air, or over the bottom of a shallow sea. When these products, therefore, of sub-marine or subterranean igneous action were contrasted with loose cones of scoriæ, tuff, and lava, or with narrow streams of lava in great part scoriacious and porous, such as were observed to have proceeded from Vesuvius and Etna, the resemblance seemed remote and equivocal. It was, in truth, like comparing the roots of a tree with its leaves and branches, which, although they belong to the same plant, differ in form, texture, colour, mode of growth, and position. The external cone, with its loose ashes and porous lava may be likened to the light foliage and branches, and the rocks concealed far below, to the roots."*

* Elements, vol i. p. 14, and vol. ii. pp. 232, 233.

Professor Phillips appears to take a similar view of this branch of geological research, and to confirm it, when he says,

"But there is yet another form of modern volcanic aggregates which it is of great importance to distinguish from the preceding, because of its bearing upon points of great importance in old geology. There are *subterranean volcanic products* which neither are poured into the sea nor thrown into the air, but secretly elaborated under the pressure of a solid covering, and effused into the fissures of the rocks.

"Although it may reasonably be allowed that the great variety of productions ejected by sub-aerial volcanoes affords a good indication of the principal mineral structures generated by volcanic action, we must be cautious not to limit our notions of their combinations in the deep parts of the earth to those which are suggested by the compounds which are determined at the surface.

"The degree of pressure, rate of cooling, and mass of ingredients which are known to be important modifying conditions of *molecular* aggregation, are wholly different at the roots and about the surface of the immense volcanic chimnies which, like Etna and the Peak of Teneriffe, become filled with the liquid rocks whenever the subterranean pressure amounts to a particular degree.

"At the base of a volcanic vent, deep in the earth or under the sea, particular mineral aggregates, slowly cooled, under great pressure, and in great masses, may, and probably do, at this day assume the large crystalline texture, and distinctness of ingredients of granite. On the bed of the sea they may flow in the state of porphyry or basalt; on the surface of the land appear as porous lava, and be blown into the air in disintegrated scoriæ, ashes, and dust."*

* Treatise, pp. 238—240.

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXII.

The evidences adduced, and the points established in the foregoing chapter, briefly applied. *Firstly.* To explain the enigma of the presence of crystallization, arising from both *aqueous* and *igneous* fusion observable in the rocky crust of the Earth. *Secondly.* To account for the existence, in the same, of mineral veins and dykes of Granite, Porphyry, Trap, &c. &c. Geological evidences in confirmation of these two branches of enquiry. A few concluding observations.

THE fusion of the injected, amorphous rocks, which everywhere so abound in fields of geological investigation, and the means employed to effect their fusion—as pre-supposed by what has been stated in the foregoing chapters—could scarcely have been better authenticated. The evidences adduced are perfectly conclusive; for, that which ought to have been the result of the application of fierce heat, under the circumstances presumed, having been premised, the experience of geologists, in their researches amongst the same rocky formations, has been adduced, and the two are found closely to coincide; while the wisdom of the method which was adopted by the Creator has been made most manifest. In contemplating the harmony which, by these two methods of investigation, is seen to prevail, we cannot fail to be impressed by the wisdom and goodness which are displayed, as well in the time as in the mode of their execution; and gratified, besides, that science has been the means of revealing these to us. For it appears evident by the two Theorems which have been

alluded to,* that the fusion of calcareous rocks is greatly facilitated by pressure, and by exclusion from the air; these conditions serving to retain their gaseous components: and that the same object is likewise attained by their being subjected in great masses to the sudden application of heat; while their gases are bound up and rendered innocuous by union with lime, or by decomposition, and the oxygen set free by the action of plants. Therefore, had this universal and intense fusion of limestone taken place in atmospheric air, and after the formation of the vegetable kingdom, so much carbonic acid would have been evolved, that animal life dependant on pulmonic action could not have existed. But by opportunely choosing the time, and performing the whole in one grand operation, all these requisite *conditions*, being foreseen, were duly provided for! By the evolution of the heat *beneath* the primeval waters, and before the formation of the atmosphere and the vegetable kingdom, the otherwise noxious gases were rendered beneficent, and subservient to the future wants of man; the same provident forethought being ever present in all the works of the Creator. By this we are, likewise, supplied with a striking corroboration of the exactness of the epoch, assigned by the inspired historian, as that of the elevation of the continents and mountains of the earth, *from its having taken place beneath the pressure of the ocean, and while as yet there was no atmosphere.*

The application of these conclusions may assist to unravel one of the greatest enigmas attending geological research. We allude to the evidences which exist in the rocky masses to lead to the undeniable conclusion, that crystallization, both by *aqueous* and *igneous* means, has been employed in their formation—a fact which, to account for seemed to require, that recourse should be had to such probabilities as could scarcely be conceded. But now, we think, we can clearly perceive, that *aqueous* crystallization was employed to aid in forming these masses in a horizontal position before the earth was made to rotate; *igneous* crystallization, arising from fierce heat occasioned by friction, having been afterwards evolved to

* 24th and 101st Theorems.

complete their structure, when they were simultaneously raised from that recumbent posture by the first diurnal movement of our sphere; while it is obvious that as this latter crystalline structure is the effect of heat; and heat, in the instances alluded to, arose from friction; and these, in turn, were occasioned by the general movement, *entre se* of the mineral masses composing the crust of the globe, then the ultimate result—crystallization—would be at its maximum amongst the more elevated and more disturbed formations; those which travelled farthest from horizontality having, consequently, evolved most heat. These natural and unconstrained conclusions supersede the necessity of recurring to supposed sudden and capricious transitions from one description of crystallization to another; and while they relieve us from this, they reveal the cause of those phenomena which intrude themselves so strongly upon the notice of geologists in these departments of their research.

What has now been said has also sufficiently proved, that *violent movement did take place* during the epoch referred to, amongst those masses of mineral matter which now constitute the rocky formations of the earth's surface; as shown by the local fusion, which was the immediate consequence; and that therefore, the foci of heat were in the centres of motion, that is, in the highest elevations.

It must, also, be obvious that if these rocks, so circumstanced, were impelled by the centrifugal impetus with so much force as to elevate the superincumbent strata; veins, or branches of the fused material, should be found not only insinuating themselves into the crevices formed by the strata, where they were shook and distorted by the general commotion; but, likewise, that these streams of fused mineral should be discovered to have burst through and overcome every obstacle, when the superincumbent masses did not separate so as to permit them to pass. On referring to the facts which have been brought to light by the investigations of geologists, it is discovered, that rocky protrusions, called veins and dykes, of the description and character here anticipated, are frequently found intersecting the whole series of formations, from the primary to the surface inclusive. But let geology speak for

itself. The *twenty-ninth* Theorem, and its accompanying evidences, state "*That when a view is taken of any geological map, it is observed that the formations represented by it are intersected by veins of granite, porphyry, senite, trap, serpentine, greenstone, &c., and by dykes of similar material, especially of trap and basalt. That whatever may be the nature or position of the formations through which they pass, the general direction of the main trunks of these veins and dykes is perpendicular to the earth's surface, although their branches frequently diverge and weld the several formations together in a remarkable manner. And that overlying masses of the same materials are frequently found on the surface, as if they had overflown from the veins while in a state of fusion.*"

"Within the primary granite," says Professor Buckland, "we find other forms of granitic matter, which appear to have been intruded in a state of fusion, not only into older fissures of the older granite, but frequently also into the primary stratified rocks in contact with it, and occasionally into strata of the transition and secondary series. These granitic injections were probably in many cases contemporaneous with the rocks they intersect; they usually assume the condition of veins, terminating upwards in small branches; and vary in dimensions from less than an inch to an indefinite width. The direction of these veins is very irregular; they sometimes traverse the primary strata at right angles to their planes of stratification, at other times they are protruded in a direction parallel to those planes, and assume the form of beds.

"Closely allied to granitic veins, is a second series of irregularly injected rocks, composed of senite, porphyry, serpentine, and greenstone, which traverse the primary and transition formations, and the lower regions of the secondary strata; not only intersecting them in various directions, but often forming overlying masses in places where these veins have terminated by overflowings at the surface. The crystalline rocks of this series present so many modifications of their ingredients, that numerous varieties of senite, porphyry, and greenstone occur frequently in the products of the eruptions from a single vent. . . . . .

"A third series of igneous rocks, is that which has formed dykes, and masses of basalt and trap intruded into, and overlaying formations of all ages, from the earliest granites to the most recent tertiary

strata. These basaltic rocks sometimes occur as beds, nearly parallel to the strata into which they are protruded, after the manner represented in the carboniferous limestone of our section. More frequently they overspread the surface-like expanded sheets of lava."*

"The last circumstance," Dr. M'Culloch states, "in the geological character of granite, relates to its distribution in the form of veins, of which there are two distinct kinds. The first lie wholly within the rock, consisting of the same materials, under slight differences in the colour and magnitude of the parts, being also connected with similar variations, of a concretionary appearance without the veinous form. . . . . . The next are much more interesting, and constitute the principal arguments respecting the posteriority of granite to the strata with which it is associated. These vary infinitely in their dimensions, extent of course, entanglement, and ramifications. At times, they are rather protuberances from the general mass than veins, while at others, they extend to great distances, insinuating themselves widely into the surrounding strata, above all, in gneiss, in which rock also they especially abound. Thus, also, their thickness varies, from many yards even to the minuteness of a thread, being simple or ramifying; and often also presenting the most intricate reticulations. In composition, the larger veins at least, sometimes, resemble the purest mass, while, in the smaller, the structure often becomes minute, as if proportioned to the size of the vein. But more commonly, the materials are crystallized on a much larger scale, producing the well-known specimens of felspar and mica, as, in these veins also, the accidental minerals enumerated in the classification are chiefly found. Yet the size of the ingredients does not bear a proportion to that of the vein; the larger crystallizations as often occurring in the small as in the large ones."†

"Thus far," says M. de la Beche, "we have only seen granite rising through and covering other rocks in considerable masses, but we have also evidence in granite veins, that the matter of the rock was in such a state of igneous fusion, as to penetrate into thin clefts opened in stratified and older rocks, by some violence, such as probably resulted from the upburst of igneous matter accompanied by elastic vapours. . . . . .

"Glen Tilt, which produced such delight to Hutton when viewed by him for the first time, presents excellent examples of the intru-

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* Bridgewater Treatise, vol. ii. pp. 4—6.

† Geology, by Dr. M'Culloch, vol. ii. pp. 95, 96.

sion of granite veins into other and stratified rocks. . . . . . . Granite veins traversing the stratified rocks are now known in various parts of the world. . . . . . Granite veins, therefore, cannot be considered as rare; on the contrary, they would appear sufficiently common, when circumstances permit good sections of the junction of the granitic mass, and of the rocks among which they appear intruded. . . . . .

"The exact composition of the granite in these veins must necessarily vary, depending much on local circumstances, for if we suppose a substance in igneous fusion to be injected into fissures of rocks, such injected matter will be subjected to different conditions. Where the fused substance cooled more suddenly, as was likely to be the case in the distant and smaller fissures, the result would be less crystalline; while in the wider clefts, and near the great heated mass, the crystallization would be more perfect, and bear the greatest resemblance to the parent mass. Consequently, in a system of granite veins, we would expect a great diversity in the aspect of the granitic matter, which generally appears to be the case.

"The trappean rocks, though there is much difficulty in separating them from the granitic, may, for convenience, be considered separately from them. They also form considerable masses, and constitute dykes and veins. When considered in the mass, they may be regarded as containing much less mica than the granitic rocks, while hornblende has become much more abundant; they also appear more abundantly among the comparatively modern deposits than the granites, though it cannot be denied that they run into the latter in a remarkable manner. . . . . .

"Trappean rocks, under their various modifications, are so common in nature, that to attempt a notice of localities, would be entirely useless. They occur mingled with the stratified rocks in every possible way; injected among the beds for considerable distances; . . . . . constituting caps of hills; . . . . . or as dykes and veins filling fissures. . . . . . Trap dykes are to be found in all parts of the world, the composition of the rock varying materially, even in the dyke itself, as we might expect from differences in the cooling and pressure, so that the central parts are not unfrequently more crystalline than the sides. . . . . .

"The above is sufficient to show, that trap, under certain conditions, may pass into serpentine. We have now to consider dykes and masses of serpentine and diallage rock, which occur under circumstances analogous to those of the trap rocks, &c. &c.

"If we regard these igneous products as a mass of matter which has successively, and during the lapse of all that time comprehended between the earliest formation of the stratified rocks and the present day, been ejected from the interior of the earth, we shall be struck with certain differences of these rocks on the great scale, which has led to their practical arrangement under the heads of granitic, trappean, serpentinous, and volcanic products as above noticed."*

"Few parts of the globe," says Professor Phillips, "except some of its vast plains and deserts, are entirely deficient of rocks which are not stratified, though the surface which they occupy is not nearly so great as that covered by the strata. Granitic and basaltic rocks compose, generally, the greater portion of the unstratified masses, as in Britain, and lie in the same relations to the strata. For granitic rocks, throughout the globe, are the most frequent axes or centres of mountain groups, and basaltic rocks fill dykes and spread in irregular cappings over the strata. It is evident, therefore, that the structure of the exterior parts of the globe, though full of local diversity, is all formed upon one general plan, and produced by similar agencies." . . . . . And again—"In Northumberland, Cumberland, and the Northern part of Yorkshire, a stratiform mass of greenstone and basalt (whin sill) is interposed in the midst of the limestone series, apparently originating in several submarine lava currents. In Derbyshire, a somewhat analogous rock, 'toadstone,' interlaminates the limestone; in the Clee Hill, a mass of basalt, 'jewstone,' has overflowed the coal. More commonly, throughout all the coalfields of Durham and Newcastle, and not unfrequently in the coal-basins of Scotland, rocks of the same kind have been injected in the fluid state into open fissures of the sandstones and shales, constituting dykes,"†

"When," says Mr. Lyell, "geologists first began to examine attentively the structure of the northern and western parts of Europe, they were almost entirely ignorant of the phenomena of existing volcanos. They found certain rocks, for the most part without stratification, and of a peculiar mineral composition, to which they gave different names, such as basalt, greenstone, porphyry, and amygdaloid. All these, which were recognized as belonging to one family, were called 'trap' by Bergmann, from *trappa*, Swedish for a flight of steps, a name since adopted very generally into the nomenclature of the

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* Manual, pp. 491—494, 496, 498, 500.

† Treatise on Geology, pp. 42, 110.

science; for it was observed, that many rocks of this class occurred in great tabular masses of unequal extent, so as to form a succession of terraces or steps on the sides of hills." And again—" Fissures have already been spoken of as occurring in all kinds of rocks, some a few feet, others many yards in width, and often filled up with earth or angular pieces of stone, or with sand and pebbles. Instead of such materials, suppose a quantity of melted stone to be driven or injected into an open rent, and there consolidated, we have then a tabular mass, resembling a wall, and called a trap dyke. It is not uncommon to find such dykes passing through strata of soft materials, such as tulf or shale, which being more perishable than the trap, are often washed away, in which case the dyke stands prominently out in the face of the precipices, or on the level surface of the country as represented in the annexed figure.

"In other cases," not unfrequent in Scotland, "the dyke having decomposed more rapidly than the containing rock, has once more left open the original fissure, often for a distance of many yards inland from the sea coast, as represented in the annexed view. There is yet another case, by no means uncommon in Scotland, where the strata in contact with the dyke, and for a certain distance from it, have been hardened so as to resist the action of the weather more than the dyke itself, or the surrounding rocks. When this happens, two parallel walls of indurated strata are seen protruding above the general level of the country, and following the course of the dyke.

"As fissures sometimes send off branches, or divide into two or more fissures of equal size, so, also, we find trap dykes bifurcating and ramifying, and sometimes they are so tortuous as to be called veins, though this is more common in granite than in trap. . . . . .

"In the Hebrides and other countries, the same masses of trap, which occupy the surface of the country far and wide, concealing the subjacent stratified rocks, are seen, also, in the sea cliffs, prolonged downwards in veins and dykes, which probably unite with other masses of igneous rock at a greater depth. The largest of the dykes represented in the annexed diagram (all vertical or nearly so), and which are seen in a part of the coast of Skye, is no less than 100 feet in width. Every variety of trap rock is sometimes found in these dykes, as basalt, greenstone, felspar, porphyry, and more rarely trachyte. . . . . .

"Some dykes of trap may be followed for leagues uninterruptedly in nearly a straight direction, as in the North of England, showing

that the fissures which they fill must have been of extraordinary length."

"A striking example" (he continues, when instancing the alteration effected by these dykes) "near Plas Newydd, in Anglesea, has been described by Professor Henslow. The dyke is 134 feet wide, and consists of a rock which is a compound of felspar and angite. Strata of shale and argillaceous limestone, *through which it cuts perpendicularly*, are altered to a distance of 30, or even, in some places, to 35 feet from the edge of the dyke. . . . . .

"As examples might be multiplied without end, I shall merely select one or two others, and then conclude.

"The rock of Stirling Castle is a calcareous sandstone, fractured and forcibly displaced by a mass of greenstone, which has evidently invaded the strata in a melted state. . . . . . 'The secondary sandstones of Skye are converted into solid quartz in several places, where they come in contact with veins or masses of trap; and a bed of quartz,' says Dr. M'Culloch, 'found near a mass of trap, among the coal strata of Fife, was, in all probability, a stratum of ordinary sandstone having subsequently been indurated and turned into quartzite, by the action of heat.'*

"The coal-measures," observes Mr. Miller, in one of his happy moods of description, "present often the appearance of vast lakes frozen over during a high wind, partially broken afterwards by a sudden thaw, and then frozen again. Their shores stand up around them in the form of ridges and mountain-chains of the older rocks, and their surfaces are ground into flat valleys and long lines of elevation. Take as an instance the scenery about Edinburgh. But whence these abrupt precipitous hills that stud the landscape, and form, in the immediate neighbourhood of the city, its more striking features? They belong, to return to the illustration of the twice frozen lake, to the middle period of thaw, when the ice broke up; and, as they are composed chiefly of matter ejected from the abyss, might have characterized equally any of the other formations. Their very striking forms, however, illustrate happily the operations of the great agencies on which, in the secondary and transition deposits, all the peculiarities of scenery depend. The molten matter from beneath seems to have been injected, in the first instance, through rents and fissures among the carboniferous shales and sandstones of the district, where it lay cooling in its subterranean matrices,

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* Elements, vol. ii. pp. 186, 212—216, 219, 220, 223, 224.

in beds and dykes, like metal in the moulds of the founder; and the places which it occupied must have been indicated on the surface, but by curves and swellings of the strata. The denuding power then came into operation in the form of tides and currents, and ground down the superincumbent rocks. The ejected masses, now cooled and hardened, were laid bare; and the softer frame-work of the moulds in which they had been cast was washed from their summits and sides, except where long ridges remained attached to them in the lines of the current, as if to indicate the direction in which they had broken its force. . . . . . The outlines of the landscape were modified yet further by the yielding character of the basement of sandstone or shale on which the plutonic beds so often rest. The basement crumbled away as the tides and waves broke against it. The ejected beds above the undermined in this process, with a vertical cleavage, induced by their columnar tendency, fell down in masses that left a front perpendicular as a wall. Each bed came thus to present its own upright line of precipice; and hence, when they rise bed above bed, as often occurs, the stair-like outline of hill to which the trap-rocks owe their name; hence the outline of the Dalmahoy Crags, for instance, and of the southern and western front of Salisbury Crags." . . . . .

And somewhat farther on he resumes—

"Mark now the geology of the ravine. For about half-way from where it opens to the shore, to where the path is obstructed by the deep mossy pool and the cascade, its precipitous sides consist of three bars or storeys. . . . . . On reaching a midway point between the beach and the cascade, this triple-barred line of precipices terminates, and a line of precipices of coarse conglomerate as abruptly begins. . . . . . The place where the sandstone ends and the basalt begins is marked by a vertical line, on the one side of which all is dark coloured, while all is of a light colour on the other. Equally marked and abrupt is the vertical line which separates the triple-barred from the conglomerate cliffs of the ravine of Eathie. The ravine itself may be described as a fault in the strata; but here is a fault, lying at right angles with it, on a much larger scale: the great conglomerate on which the triple-bars rest has been cast up at least two hundred feet, and placed side by side with them. And yet the surface above bears no trace of the catastrophe. Denuding agencies of even greater power than those which have hollowed out the cliffs of the neighbouring coast, or whose operations have been prolonged

through periods of even more extended duration, have ground down the projected line of the upheaved mass to the level of the undisturbed masses beside it. Now, mark further, as we ascend the ravine, that the grand cause of the disturbance appears to illustrate, as it were, and that very happily, the manner in which the fault was originally produced. The precipice over which the stream leaps at one bound into the mossy hollow, is composed of granitic gneiss, and seems evidently to have intruded itself with much disturbance, among the surrounding conglomerate and sandstones. A few hundred yards higher up the dell, there is another much loftier precipice of gneiss, round which we find the traces of still greater disturbance; and higher still, yet a third abrupt precipice of the same rock. The gneiss rose, trap-like, in steps, and carried up the sandstone before it in detached squares. Each step has its answering fault immediately over it; and the fault where the triple-bars and the conglomerate meet is merely a fault whose step of granitic gneiss stopped short ere it reached the surface."*

These passages, taken from the works of some of the most scientific of our geological writers, will have sufficiently explained what is meant by *dykes* and *veins*, and have exhibited the characters of *mineral protrusions:* but *geological maps* on sectional principles† can alone make completely evident, at one view, what we are more especially desirous to impress, at present, on the mind, namely—the *general direction* which these igneous injections appear to have taken, as they came upwards to burst forth and overflow upon the land.

Without taking into account their veinous ramifications or more minute inflexions, their course, wherever it has been practicable to examine this continuously, seems to be *perpendicular to the surface.* Without any intention to assert, that these protrusions proceed from or reach the centre, we merely mean that a parallel straight line passing down the *main trunk* of trap or basalt dykes, and prolonged *imaginarily* would con-

* Old Red Sandstone, pp. 244—246, 256—258.

† Such as that constructed by Professor Buckland, and appended to his valuable work, the "*Bridgewater Treatise;*" the views in the several works quoted, and above all, Mr. Knipe's Geological Map of Great Britain and Ireland and part of France, where these dykes and veins are admirably pourtrayed.—AUTHOR.

verge, until they all met in one common centre—the centre of the earth.

Now, it must be obvious, that upon a surface so diversified by elevations and depressions, or, in other words, so *uneven* as that of the earth, where the depth subjected to geological examination is so insignificant when compared with the radius, and when it is considered, that the researches which have revealed these igneous protrusions, and have led to the construction of those sectional maps, have been made in some of the least level parts of the earth's surface—the natural inference to be drawn from all these circumstances is, that no *single* cause could have occasioned any mineral matter, in a state of fusion, to have observed so uniform a direction on such a diversified surface throughout the whole of a spherical body.

The origin of this *uniformity* of *course* must be sought for, not in one, but in a combination of causes, which, unitedly, may be considered commensurate with the effect.

To account for the origin of that which, while it is everywhere the same on the surface of a spherical body, affords symptoms of having travelled thither, we are constrained to look to the centre; and, moreover, the imaginary prolongations of these trappean and basaltic dykes point towards the same direction. Nevertheless, we deny that there resides at the earth's centre any cause or power adequate to have sent forth these streams of melted mineral; a denial which will appear more just, after we have perused the observations immediately following.

While we acknowledge the necessity of looking *towards* the centre for an effect which is everywhere alike on the surface, and while, at the same time, we set aside the centre itself of the earth as the site of the common cause; and while, in lieu thereof, we consider the centrifugal impetus, arising from the protorotation of the earth to have been the *primum mobile* of these protrusions; we profess our belief, that neither could centrifugal impetus alone, have given direction to them. Streams of melted mineral matter proceeding *solely* from, or what is equivalent, in straight lines from an axis of gyration, *extending the whole semi-diameter of the earth, must have cut the concentric shell in degrees of obliquity, according to their*

parallels of latitude. This, had it taken place, would neither have fulfilled the design which the benignant Creator had in view, nor have caused the protrusions to run in the direction in which they are seen by geologists actually to do. The same difficulty will be felt, even should we add to the above position, the fact of the upheaving or tilting, out of horizontality, of the strata by the same centrifugal force; as it will appear evident, after a little reflection, that veins proceeding in perpendicular lines from the common radius of gyration, the axis of the earth, would (in this latter case) have cut the strata, especially those within the tropics, in directions nearly parallel to the upheaved posture which their lines of stratification had then assumed.

We have ever maintained, that the first rotation of the earth around its axis occasioned a sudden, violent, and general movement among the various masses of mineral matter which at that time composed its concentric rocky crust; and, as a natural result of this movement, *inter se*, the evolution by means of friction, of *intense heat;* and it is when we come to investigate into the *origin* and *direction* of these dykes and other *mineral protrusions*, that more than ever we recognize the soundness of those assumptions. Without *movement amongst* the stony materials of the earth's original shell there could have been no *heat;* without *heat* there would have been neither dykes, veins, nor other overflowings of fused mineral matter. Their *mere existence*, therefore, testifies to the fact of those fierce heats having been engendered. Whilst the *direction they have pursued* not only affords evidence to the same effect, but shows that the *expanding influence of heat* co-operated with the *centrifugal force* in constraining them to *adopt a course somewhat between the two, and towards the surface from every centre of heat*, or, what is the same thing, *from every mountain range*, and thus there was conferred upon them that remarkable coincidence of direction throughout all varieties and inequalities of surface, which no single force could have caused them, under any circumstances whatever, to have pursued.

From what has been said it must appear evident, that any attempt to have explained the origin and direction of these *mineral protrusions* without reference to centrifugal impetus, would have been as unsuccessful as, on the other hand, any

endeavour to have accounted for them by *that force alone*, would have been unsatisfactory and inconclusive. Their existence and their geological position are alike due to that inevitable modification of the centrifugal force, occasioned by the heat which that motion engendered. When it raised the heat which melted the mineral matter, it likewise propelled the whole towards the periphery; and both together forced these streams of fused material to find the nearest vent upon the surface, as so many outlets for the extension of the matter which an increase of volume, attendant on that of temperature, had occasioned on the earth's crust; whilst the Creator, by his wisdom and power, made use of all these concomitant circumstances to weld the shattered fragments of the earth's outer crust securely together in the very midst of its convulsions, and to bind stratum to stratum, and rock to rock, in the most perfect and enduring manner by a universal protrusion of veins and dykes, which, after perforating the whole, were clenched and rivetted by their overflowings on the surface—the mineral bolts and bars of the earth's outer crust! While these veins and dykes afford us yet other undoubted indications. They show us, in the most undeniable manner, whereabouts the surface of the earth then was; for, as long as they had to perforate rocky masses, they proceeded in straight lines, generally speaking, under the combined influence of a superior force, and the opposition which the perforated masses, by their density, offered to their lateral dispersion. But so soon as they reached the surface, or the looser materials of the more recent deposits, having no longer dense substances on each side to confine them, they spread out and around in obedience to the joint laws of gravity and centrifugal impetus; the latter inducing them to overflow, the other causing the ejected mass to fall down by its own weight: hence we are authorised to conclude, that wherever accumulations of fused rocks are found, the surface either was there at the time of the earth's first rotation, or there were present only materials of less density than the overflowing masses, amongst which they conducted themselves almost as they would have done upon the altogether external surface of the forming continents; while the abrading influence of the primitive ocean, as it simul-

taneously rushed from the polar regions towards the equator, to complete the static condition of liquidity under rotation, would greatly contribute to these denuding effects, and leave around these impervious barriers incontestible traces behind it of the path which it hurriedly followed, as it swept past them in its impetuous course.

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXII.

FAULTS or FISSURES described. Geological evidences of their existence. Application of these data to the COAL MEASURES, considered to have been the uppermost strata of the Non-rotatory Sphere. Found to correspond. METALLIC VEINS, described; geological and other scientific data descriptive of these interesting portions of the rocky crust of the earth.

HAVING thus been enabled to indicate the probable origin of the *mineral veins* which proceed in directions from the centre towards the circumference, we shall in this chapter endeavour to explain, as for as the Dynamical Theory will enable us, whence we consider those called "fissures" or "faults," which proceed in a contrary direction, or from the surface towards the interior of the earth's crust, to have arisen. They are taken notice of in the *thirtieth* Theorem, and its accompanying evidence, which state, "*That two distinct classes of mineral veins are found to exist in the earth's outer crust—one of which proceeds from inwards outwards, having their bases in the interior, and their apici nearest to the surface; and the other termed Faults and Fissures proceeding from outwards inwards, with their apici in the interior and their bases on or near to the surface.*"

"In our last chapter," says Professor Buckland, "we considered the advantages of the disposition of the carboniferous strata in the form of basins. It remains to examine the further advantages that arise from other disturbances of these strata by *faults* or *fractures*, which are of great importance in facilitating the operations of coal

mines. . . . . . The component strata of a coal field are divided into insulated masses, or sheets of rock, of irregular form and area, not one of which is continuous in the same plane over any very large district; but each is usually separated from its next adjacent mass by a dam of clay, impenetrable to water, and filling the fissure produced by the fracture which caused the fault.

"If we suppose a thick sheet of ice to be broken into fragments of irregular areas, and these fragments again united, after receiving a slight degree of irregular inclination to the plane of the original sheet, the re-united fragments of ice will represent the appearance of the component portions of the broken masses, or sheets of coal measures we are describing. The intervening portions of more recent ice, by which they are held together, represent the clay and rubbish that fill the faults, and form the partition walls that insulate these adjacent portions of strata which were originally formed, like the sheet of ice, in one continuous plane. Thus, each sheet, or inclined table of coal measures, is inclosed by a system of more or less vertical walls of broken clay, derived from its argillaceous shale beds, at the moment at which the fracture and dislocation took place; and hence have resulted those joints and separations which, though they occasionally interrupt at inconvenient positions, and cut off suddenly the progress of the collier, and often shatter those portions of the strata that are in immediate contact with them, yet are, in the main, his greatest safeguard, and are, indeed, essential to his operations."*

"The immense violence," observes Professor Playfair, "which has accompanied the formation of mineral veins, is particularly marked by the *slips*, and *shifts* of the strata on each side of them, all tending to show that mighty changes have taken place in those regions, which our imagination erroneously paints as the abode of silence and rest. . . . . . Mineral veins contain abundant marks of the most violent and repeated disturbance. And it appears most likely, that fissures in the strata were made, at least in many instances, and the matter poured into them, nearly at the same time, both being effects of the same cause,—the expansive force of subterraneous heat. . . . . .

"If all these circumstances are put together, there appears but one conclusion to be drawn from them. The manifest marks of some power which could lift up fragments of rocks from their native

* Bridgewater Treatise, vol. i. pp. 541—544.

places, distant several hundred yards from their present situations; place them upright on their edges, encompass them with solid rock quite heterogeneous to themselves, and bestow upon them a great addition of solidity and induration.

"It is indeed impossible, that the effects of motion and heat can be more clearly expressed than by these symptoms; or the subject in which these powers resided, more distinctly pointed out."*

"Faults," according to Mr. Conybeare, "consist of fissures, traversing the strata, extending often for several miles, and penetrating to a depth in very few instances ascertained; they are accompanied by a subsidence of the strata on one side of their line, or (which amounts to the same thing) an elevation of them on the other; so that it appears, that the same force which has rent the rocks thus asunder, has caused one side of the fractured mass to rise, or the other to sink. The fissures are generally filled by clay."†

"As we can scarcely conceive such a general and simultaneous movement of the inferior strata," says M. de la Beche, when treating of the red sandstone group, "immediately preceding the first deposits of the red sandstone series, that every point on which it reposes was convulsed and threw off fragments on the sudden elevation of lines of strata, we should rather look to certain foci of disturbance for the dispersion of debris. The accumulation of the larger fragments, and the relative amount of conglomerate, would, under this hypothesis, be greatest nearest to the disturbing cause; and amid such turmoil we might anticipate the occurrence of igneous rocks thrown up at the same period. . . . . . But notwithstanding the abundance of the greenstones and dark coloured porphyries, not a fragment of them has yet been discovered among the conglomerates, though rolled portions of the red porphyries are so abundant. . . . . . This fact seems to attest that the dark coloured trappean rocks did not exist in such a state, when fragments of slate, limestone, &c. &c., were broken off, that they could be fractured and broken with the rest: though it does not show that trap rocks may not have been protruded at the time of convulsion, thus aiding the confusion, and in a great measure causing it. On the contrary, we have every reason to consider that the eruption of trap rocks did accompany (if partly not produce), the disruption of strata, whence the fragments in the conglomerate were derived: for

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* Illustrations of Hutt. Theory, Playfair's Works, vol. i. pp. 76, 258, 301.

† Geology of England and Wales, part i. p. 348.

we have seen that red quartziferous porphyry, in mass, surmounts a portion of the red conglomerate; and the occurrence of trappean rocks so blended with the conglomerates that lines of separation cannot be drawn between them. Now, if igneous rocks were ejected, a conclusion which the facts appear to justify, at the time of the production of the conglomerate, there would seem no reason why, under favourable circumstances, the two should not be in some measure blended with each other. Another circumstance also lends probability to this view, and that is, the occurrence of pebbles cemented in certain inferior beds by a kind of semi-trappean paste, containing crystals of that variety of felspar named murchisonite by Mr. Levi. Such a cement might possibly have resulted from the upburst of igneous rocks, accompanied by various gases beneath a mass of water, when some of the erupted matter may have so combined as to form a cement, in which crystals of murchisonite became developed: without some such hypothesis this cement seems of very difficult explanation."*

"Numerous rents may often be seen," says Mr. Lyell, "in rocks which appear to have been simply broken, the separated parts remaining in the same places; but we often find a fissure, several inches or yards wide, intervening between the disunited portions.

"These fissures are usually filled with fine earth and sand, or with angular fragments of stone, evidently derived from the fracture of the contiguous rocks.

"It is not uncommon to find the mass of rock on one side of a fissure thrown up above, or down below, the mass with which it was once in contact on the other side. This mode of displacement is called a shift, slip, or fault.

"'The miner,' says Playfair, describing a fault, 'is often perplexed in his subterraneous journey, by a derangement in the strata, which changes at once all those lines and bearings which had hitherto directed his course.' . . . . .

"We may occasionally see exact counterparts of these slips, on a small scale, in pits of fine loose sand and gravel, many of which have doubtless been caused by the drying and shrinking of argillaceous and other beds, slight subsidences having taken place from failure of support.

"In the present state of our ignorance of the causes of subsidence, an hypothesis which can explain the great amount of displacement

* Manual of Geology, pp. 403, 404.

in some faults, on sound mechanical principles, by a succession of movements, is far preferable to any theory which assumes each fault to have been accomplished by a single upcast or downthrow of several thousand feet. For, we know that there are operations now in progress at great depths in the interior of the earth, by which both large and small tracts of ground are made to rise above and sink below their former level, some slowly and insensibly, others suddenly and by starts, a few feet or yards at a time; whereas there are no grounds for believing that, during the last 3,000 years at least, any regions have been either upheaved or depressed, at a single stroke, to the amount of several hundred, much less several thousand feet."*

"In some cases," says Professor Phillips, "instead of acclinal or declinal slopes to or from an axis, we have a complete *fracture* of the mass of strata along a vertical or inclined plane, parallel to which the beds on one side are uplifted, and on the other depressed. This is called a *fault* or *slip*; almost every coal district and mining region in the world is full of such, though their number is, upon the whole, very much greatest in elevated districts, and least in the youngest strata.

"The extent of displacement on one side of such fault is sometimes only a few inches; in other cases 10, 100, or 1,000 feet or yards. The great Craven fault and Cross Fell fault in the North of England is complicated with a narrow anticlinal axis, the extent of displacement produced by both is 1,000, 2,000, 3,000, or even 4,000 feet (Diagram, No. 7).

"The jointed structure of rocks of the carboniferous system has been minutely investigated. In the Geology of Yorkshire, vol. ii., it is shown, from eighty-five observations in the carboniferous system, that in the mountain limestone and coal tracts of Yorkshire, the *long joints* affect certain principal directions, so that two positive axes, in which these divisional planes are most frequent, are traced at right angles to one another; and two negative axes in which *no* long joints have been observed, also at right angles to each other.

"The axes of frequent joints run N.N.W. and S.S.E., and E.N.E. and W.S.W., the negative axes are N.E. by N., and N.W. by W. This singular result of observation harmonizes with the principal directions of mineral veins in the district bordering on the great Cross Fell and Craven faults; it also bears a close analogy with the

* Elements, vol. i. pp. 128, 129, 131, 135.

deductions from the mechanical theory of Mr. Hopkins (Cambridge Trans., 1836), as to the production of planes of fissures, at right angles to each other, in cases of continuous pressure being applied to large areas of the earth's lamellar crust.

Magnitude of disturbance.—The extent of the dislocations effected by particular convulsions is really enormous, and puts to shame the utmost exertion of a succession of modern earthquakes for many thousands of years. The Penine region of the north of England, elevated posterior to the era of coal measures, is defined on three sides by dislocations of 1,000, 2,000, 3,000, and more feet; and there is, perhaps, as little reason to suppose that more than one effort was employed on any one of these sides, as in the case of an ordinary fault! Such faults, indeed, sometimes occasion depression of several hundred feet; but seldom for such great lengths as the Penine and Craven disturbances."*

Now, if we imagine the surface of a level sphere enveloped in certain portions of its area by concentric and alternating strata of coal and clay, or shale, in a semi-indurated condition, and then suppose that, by a sudden revolution, it is greatly enlarged—and this enlargement is filled up by the protrusion of amorphous rocks among its stratified masses, whereby great elevations and depressions are caused upon its surface—we shall recognise at once the origin of these *fractures* or *faults*, in the secondary strata. Indeed, there is no other way in which the coal measures, then constituting partially the surface of our globe, could possibly have accommodated themselves to a simultaneous enlargement of surface, and to a change of inclination. They must unavoidably have been rent and split into detached portions, in precisely the same manner as a bed of clay now does when it contracts by drought and heat, and becomes too small to extend over the surface which it formerly covered; with this difference, however, that in the one case the clay contracts; while, in the other, the surface became enlarged.

It must likewise be obvious, that the fissures or spaces thus occasioned between the cuboidal masses of coal, clay, sandstone, &c., could not be entirely filled up by clay derived from the

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* Treatise, pp. 62, 63, 107, 108, 260, 261.

alternating shale beds of the corboniferous series themselves, because there is no way whereby a determinate quantum of strata, which once covered a certain extent of area, could be made to cover a greater extent of surface, unless by spreading out, or what is the same, by undergoing a corresponding reduction in vertical thickness; but as this has never been even dreamt of by any one, it follows, that the original quantum of matter, having maintained its previous thickness, could not, *from its own body*, supply the void occasioned by the enlargement of surface. Clay from the shale beds may, and no doubt did, filter in along with other matter from above; but for the reasons assigned, it must have been to a limited extent. On the other hand, we shall find a ready and satisfactory solution of the question, if we attribute the matter contained in these partitions to enfiltration from above, while the surface of the earth (although rotating), was as yet submerged in the primeval ocean. At the time of its first rotation the waters were surcharged, as will be shown presently, with mineral *debris* of all kinds; and these, in rushing in to fill up the chasms caused by the enlargement of the earth's surface, would carry in a portion of their mineral contents along with themselves, and fill them with a mixture of "clay and rubbish," which afterwards becoming indurated, formed those useful, though sometimes embarrassing, compartments into which the secondary strata, and especially the coal fields, are found so frequently to be divided.

This view of the subject explains, likewise, the cause of these cuboidal masses being higher on one side of the fault than the other. For this is precisely the position in which masses of that form, if free to move, would arrange themselves, when raised up from a horizontal position into one of verticality, *provided the spaces between them were filled with a substance of so soft a consistency as to offer no opposition to their movement.* This, besides, is the *only* way in which the phenomena attendant on these faults, and inter-contained cuboidal masses can be throughly explained; for, *there is no direction, in which any mass injected from beneath—supposing this to be the cause of the dislocation—could have raised up the strata on the one side and depressed them on the other.* If, on the other hand,

the cause is presumed to have acted *from above downwards*, the corresponding depression must have been equal on either side of the downwardly intruded mass: therefore, the force which occasioned these phenomena must have been *general*, occasioning a universal elevation of individual masses, and a corresponding relative inequality of level, or apparent depression between any two of their nearest edges. Cuboidal masses of equal thickness laid upon an inclined plane would assume a similarly relative position to each other. These considerations, the legitimate offspring of the Dynamical Theory, also tend to reconcile the conflicting opinions as to the *aqueous* or *igneous* origin of veins, by showing, that there may exist veins proceeding from both causes, easily to be accounted for when looked upon in the light with which we view them, although resisting a cordial reconciliation when they are wholly attributed to any *one* of these causes.

Finally. From all that has been said on this branch of our subject it appears evident, *that the dislocations and corresponding faults in the secondary strata, were occasioned by the rotation of the earth around its axis, while yet its whole surface was under water; that is, at some period between the* FIRST *and the* THIRD *days of the Mosaic week.*

We come now to consider a third and distinct class of veins found intersecting the earth's outer crust, and whose origin is involved in considerable obscurity. We allude to the METALLIC VEINS. It is deferentially presumed, however, that the Dynamical Theory, by having made so manifest the existence of distinct centres or foci of heat, while it has explained the origin of the other two classes of veins and fissures, may, happily, be capable of also throwing some light upon these arcanæ of the creation. Yet it is necessary to premise, that in attempting this, we shall have occasion to make direct allusion to mineralogical and geological discoveries and conceptions, which, although they afford bright and vivid glimpses into these secret recesses of nature, are still incomplete and immatured, and, therefore, we trust that every reasonable allowance will be made, should what we have to say on this subject amount only to well-grounded probabilities, pointing the way to the confirmation hereafter of these surmises, when their

attendant circumstances shall have become more fully developed.

Let us then see, in the first place, what the Theorems which refer to them assert regarding these veins. The *hundred-and-fifth* Theorem states, "*That* METALLIC ORES—*which are metals in combination either with sulphur, charcoal, oxygen, and even with other metals, or with silica, alumina, and lime—are commonly found in narrow fissures, termed lodes or veins, predominating in the primitive and transition series, and which are usually filled up with some crystalline mineral different from the rock in which they occur.*

"*That they are supposed to have been produced by electrical agency developed by the violent contact and friction of rocks of various kinds containing, previously, metalliferous elements. And, that the same lode frequently contains a metallic pyrite, and, within a short distance, separated merely by a common argillaceous substance, some other modification of the same metal, whilst the lode itself is generally saturated with water containing various salts.*"

Considering the fact of the *mere existence* of these veins to be too well authenticated to require any further evidence, we shall go on to enquire into their *direction*, and other *conditions*, which are much more essential to the establishment of our present subject. For this purpose we shall recapitulate the Theorem which follows the one just given, wherein it is stated, "*That when a general view is taken of* METALLIC VEINS *on any geological map,* the following prominent and characteristic features present themselves to the observation, namely:—*

1. *That they either entirely originate from, or predominate in, the primary masses and the transition series.*

2. *That, generally, they run in straight lines, and in directions oblique to the surface; veins of different materials cutting each other at right angles, and, not unfrequently, perpendicular to the lines of stratification.*

3. *That, unlike faults and dykes, mineral veins do not cause*

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* The geological maps here alluded to are those displaying sectional views of the various formations, veins, &c., such as those constructed by Dr. Buckland, Mr. Lyell, Mr. Knipe, and others.

dislocation of the strata; but seem, whilst they have evidently passed through, to have left them undisturbed in their relative positions. And

4. *That when veins cut each other at right angles, they are usually different in their contents.*"

We shall commence the evidences, which relate to this important branch of geological research, by a few quotations from Prof. Playfair's Illustrations of the Huttonian Theory, the perspicuity of which is only surpassed by the correctness of the style in which they are given. Circumstances necessarily constrain us to abridge these passages, which we regret, and would, therefore, recommend the work itself to our readers:—

"The unstratified minerals exist," observes the Professor, "either in veins intersecting the stratified, or in masess surrounded by them. Veins are of various kinds, and may, in general, be defined as separations in the continuity of a rock, of a determinate width, but extending indefinitely in length and depth, and filled with mineral substances different from the rock itself. The mineral veins, strictly so called, are those filled with crystallized substances, and containing the metallic ores. That these veins are of a formation subsequent to the hardening and consolidation of the strata which they traverse, is too obvious to require any proof; and it is no less clear from the crystallized and sparry structure of the substances contained in them, that these substances must have concreted from a fluid state. Now, that this fluidity was simple, like that of fusion by heat, and not compound, like that of solution in a menstruum, is inferred from many phenomena. It is inferred from the acknowledged insolubility of the substances that fill the veins in any one menstruum whatsoever; from the total disappearance of the solvent, if there was any; from the complete filling up of the veins by the substances which that solvent had deposited; from the entire absence of all the appearances of horizontal or gradual deposition; and, lastly, from the existence of close cavities, lined with crystals, and admitting no egress to anything but heat. . . . . . The metals contained in the veins which we are now treating of, appear very commonly in the form of an ore mineralized by sulphur. Their union with this latter substance can be produced, as we know, by heat, but hardly by the way of solution in a menstruum, and, certainly, not at all if that

menstruum is nothing else than water. The metals, therefore, when mineralized by sulphur, give no countenance to the hypothesis of aqueous solution; and still less do they give any when they are found native, as it is called; that is, malleable, pure, and uncombined with any other substance. . . . . . Gold, however, the most perfect of the metals, is found native most frequently; the others more rarely in proportion nearly to the facility of their combination with sulphur. Of all such specimens it may be safely affirmed, that if they have ever been fluid, or even soft, they must have been so by the action of heat; for, to suppose that a metal has been precipitated pure and uncombined from any menstruum is to trespass against all analogy, and to maintain a physical impossibility. But it is certain that many of the native metals have once been in a state of softness, because they bear on them impressions which they could not have received but when they were soft. Thus, gold is often impressed by quartz and other stones, which still adhere to it, or are involved in it. Specimens of quartz, containing gold and silver shooting through them, with the most beautiful and varied ramifications, are everywhere to be met with in the cabinets of the curious; and contain in their structure the clearest proof that the metal and the quartz have both been soft, and have crystallized together. Native copper is very abundant, and some specimens of it have been found crystallized. Here the crystallization of the metal is a proof that it has passed from a fluid to a solid state; and its purity is a proof that it did not make that transition by being precipitated from a menstruum. Again, pieces of native manganese have been found possessing so exactly the character peculiar to that metal, when reduced in our furnaces, that it is impossible to consider them as deriving their figure and solidity from any cause but fusion. . . . . . All these appearances conspire to prove, that the materials which fill the mineral veins were melted by heat, and forcibly injected, in that state, into the clefts and fissures of the strata. . . . . . In the view now given of metallic veins, they have been considered as traversing only the stratified parts of the globe. They do, however, occasionally intersect the unstratified parts, particularly the granite, the same vein often continuing its course across rocks of both kinds, without suffering any material change. . . . . . It is material to remark, that, though metallic veins are found indiscriminately in all the different kinds of rock, whether stratified or otherwise, they are most abundant in the class of primary schisti. . . . . . This preference which the metals appear to give to the primary strata, is

very consistent with Dr. Hutton's theory, which represents the rocks of that order as being most changed from their original position, and those on which the disturbing forces of the subterraneous regions have acted most frequently, and with greatest energy. The primary strata are the lowest also, and have the most direct communication with those regions from which the mineral veins derive all their riches."*

"Metallic veins," says Professor Buckland, "are of most frequent occurrence in rocks of the primary and transition series, particularly in those lower portions of stratified rocks which are nearest to unstratified crystalline rocks. They are of rare occurrence in secondary formations, and still more so in tertiary strata."

In a note he adds—

"Mons. Dufrenoy, has recently shown that the mines of Hæmatite and Spathic iron in the Eastern Pyrenees, which occur in limestones of three ages, referable severally to the transition series, to the lias, and to the chalk, are all situated in parts where these limestones are in near contact with the granite; and he considers, that they have all, most probably, been filled by the sublimation of mineral matter into cavities of the limestones, at, or soon after, the time of the elevation of the granite of this part of the Pyrenees. The period of this elevation was posterior to the deposit of the chalk formation, and anterior to that of the tertiary strata. These limestones have all become crystalline where they are in contact with the granite; and the iron is in some places mixed with copper pyrites, and argentiferous galena."

With regard to the general direction of these veins, Professor Buckland observes—

"A further result attending the disturbances of the surface of the earth has been, to produce rents or fissures in the rocks which have been subjected to these violent movements, and to convert them into receptacles of metallic ores, accessible by the labours of man. The greater part of metalliferous veins originate in enormous cracks and crevices, penetrating irregularly and obliquely downwards to an unknown depth, and resembling the rents and chasms which are produced by modern earthquakes. The general disposition of mineral

* Illustrations of the Huttonian Theory, pp. 72—81.

veins within these narrow fissures will be best understood by reference to our first section. The narrow lines that pass obliquely from the lower to the upper portion of this section, represent the manner in which rocks of various ages are intersected by fissures which have become the receptacles of rich treasures of metallic ore. These fissures are, more or less, filled with various forms of metalliferous and earthy minerals, deposited in succession, and often in corresponding layers on each side of the vein."

In another part of the same work he adds—

"This section, reduced from Thomas's Survey of the Mining District of Cornwall, exhibits the manner in which the granite and slate near Redruth are intersected by metalliferous veins, terminated abruptly at the surface, and descending to an unknown depth; these veins are usually most productive near the junction of the granite with the slate, and where one vein intersects another. The mean direction of the greatest number of them is nearly from E.N.E. to W.S.W. They are intersected, nearly at right angles, by other and less numerous veins, called cross courses, the contents of which usually differ from those of the E. and W. veins, and are seldom metalliferous.

"The granite, and Killas and other rocks, which intersected them, *e. g.* dykes and intruded masses of more recent granite, and of various kinds of porphyritic rocks called Elvans, are considered to have occupied their present relative positions before the origin of the fissures which form the metalliferous veins that intersect them all."*

Mr. Lyell is rather concise on this branch of geological research, but quite conclusive. He states that—

"Granite, syenite, and those porphyries which have a granitiform structure, in short all plutonic rocks, are frequently observed to contain metals, at or near their junction with stratified formations. On the other hand, the veins which traverse stratified rocks are, as a general law, more metalliferous near such junctions than in any other positions. Hence it has been inferred, that these metals may have been spread in a gaseous form through the fused mass, and that the contact of another rock, in a different state of temperature, or sometimes the existence of rents in other rocks in the vicinity, may have caused the sublimation of the material."

* Bridgewater Treatise, vol. i. pp. 548, 549, and vol. ii. pp. 107, 108.

And at another place he says—

"Near Champoleon, a granite composed of quartz, black mica, and rose-coloured felspar, is observed partly to overlie the secondary rocks, producing an alteration which extends for about thirty feet downwards, diminishing in the beds which lie farthest from the granite. In the altered mass the argillaceous beds are hardened, the limestone is saccharoid, the gritz quartzose, and in the midst of them is a thin layer of imperfect granite. It is also an important circumstance, that near the point of contact, both the granite and the secondary rocks become metalliferous, and contain nests and small veins of blende, galena, iron and copper pyrites."*

Professor Phillips, with respect to this point, says—

"Mineral veins abound in particular parts of the carboniferous rocks, chiefly in the limestone districts, and near to some considerable dislocations or axis of distinct elevation.

"Scarcely a mine in the British Islands is worked in the old red sandstone, or true coal measures; very few are established in the districts which, like a large part of the Irish limestone, are removed from axes and centres of disturbance.

"But the dislocated mountain limestone of Cumberland, Durham, Yorkshire, Derbyshire, Flintshire, Mendip, and South Wales, and partially that of Belgium and Silesia, is characterized by prevalence of veins of lead, copper, calamine, and oxide of iron. There is seldom found in these districts the same great variety of metallic ores, as in the older primary tracts; the vein stuff, the matrix of the ore, differs according to locality; fluor-spar abounds in the mines of Alaston Moor, &c., carbonate of barytes in Derbyshire. It is seldom that the same mining districts, almost never the same veins, yield copper and lead in abundance.

"Most of the veins of fissure are accompanied by dislocation (faults), sometimes to the extent of several hundred feet, sometimes only a few inches. They pass through the stratiform basalt of Northumberland and Yorkshire, and *yield ore in it abundantly*. . . . Pipe veins are of less frequent occurrence and inferior interest.

"The same phenomena of some veins crossing and cutting others occur in this district as in the older strata, and the same tendencies to peculiar directions are recognised; the bearing veins running

* Elements, vol. ii. pp. 342, 343, 363.

generally East-North-East or nearly so, and the cross courses North-by-West, in the North of England and Flintshire."

At another part of his work he declares

"It to be a general truth, that metallic veins abound in proportion to the proximity of the situation to axes of dislocation, and eruptions of pyrogenous rocks."*

For a more perfect conception of the direction in which these veins intersect each other, and run through the rocks composing the earth's outer crust, we beg to refer our readers to any of those geological maps which we have enumerated, and which embrace extended areas of primary formation; for by them it will be seen, that the metalliferous veins generally cut one another at right angles; while they penetrate each successive formation without causing the slightest dislocation, or derangement of the relative positions of contiguous rocks.

Having perused these evidences, which are meant to show the *localities*, and the usual *direction* of metallic veins, we shall next endeavour to acquire some information as to their supposed *origin*, or the causes which produced them.

"Several hypotheses," according to Professor Buckland, "have been proposed to explain the manner in which these chasms in solid rocks have become filled with metallic ores, and with earthy minerals, often of a different nature from the rocks containing them. Werner supposed that these veins were supplied by matter descending into them from above, in a state of aqueous solution; whilst Hutton and his followers imagined that their contents were injected from below in a state of igneous fusion. A third hypothesis has been recently proposed, which refers the filling of veins to a process of *sublimation* from subjacent masses of intensely heated mineral matter, into apertures and fissures of the superincumbent rocks. A fourth hypothesis considers veins to have been slowly filled by *segregation*, or infiltration, sometimes into contemporaneous cracks and cavities, formed during the contraction and consolidation of the originally soft substances of the rocks themselves; and more frequently into fissures produced by the fracture and dislocation of the solid strata. Segre-

* Treatise, pp. 111, 112, 91.

gation of this kind may have taken place from electro-chemical agency, continued during long periods of time."*

In another part of his work, Professor Buckland gives some particulars respecting Mr. Fox's views and experiments, which we have much pleasure in extracting, in consequence of the surmise that *they contain "the rudiments of the true theory of metallic veins.*"

"The following observations," says he, "by Mr. R. W. Fox, in a recent communication to the Geological Society of London, April, 1836, appear to contain the rudiments of a theory, which when maturely developed, promises to offer a solution of this difficult and complex question:—

"'If it be admitted that fissures may have been produced by changes in the temperature of the earth, there can be little difficulty in also admitting that electricity may have powerfully influenced the existing arrangements of the contents of mineral veins; how are we otherwise to account for the relative positions of veins of different kinds with respect to each other, and likewise for their contents in reference to the rocks which they traverse, and many other phenomena observable in them of a very decided and definite character? Copper, tin, iron, and zinc, in combination with the sulphuric and muriatic acids, being very soluble in water, are, in this state, capable of conducting voltaic electricity; so, if by means of infiltration, or any other process, we suppose the water to have been impregnated with any of these metallic salts, the rocks containing different salts would undoubtedly become in different or opposite electrical conditions; and hence, if there were no other cause, electrical currents would be generated, and be readily transmitted through the fissures containing water, with salts in solution; and decompositions of the salts, and a transference of their elements, in some cases to great distances, would be the natural result. But, on the known principles of electro-magnetism, it is evident that such currents would be more or less influenced in their direction and intensity by the magnetism of the earth. They cannot, for instance, pass from N. to S., or from S. to N. so easily as from E. to W., but more so than from W. to E. The terrestrial magnetism would, therefore, tend, in a greater or less degree, to direct the voltaic currents through those fissures which might approximate to an east and west bearing,

* Bridgewater Treatise, vol. i. pp. 550—552.

and, in separating, the saline constituents would deposit the metal within or near the electro-magnetic rocks, and the acid would be determined toward the electro-positive rock, and probably enter into new combinations; or the sulphuric acid might, by means of the same agency, be resolved into its elements; in which case the sulphur would take the direction of the metal, and the oxygen of the acid, and in this way the metallic sulphurets may have derived their origin; for, if I mistake not, the metallic sulphates, supposing them to have been the prevailing salts, as at present, would be fully adequate to supply all the sulphur required by the same metals to form sulphurets; indeed, more than sufficient, if we deduct the oxides of tin, and other metalliferous oxides found in our mines. The continued circulation of the waters would, in time, bring most of the soluble salts under the influence of these currents, till the metals were, in great measure, separated from their solvents, and deposited in the east and west veins, and near the rocks to which they were determined by the electric currents.' "

And again—

"Mr. Fox has found by experiment that when a solution of muriate of tin is in the voltaic current, a portion of the metal is determined towards the negative pole, whilst another portion in the state of an oxide passes to the positive pole. This fact appears to him to afford a striking illustration of the manner in which tin and copper have been separated from each other in the same vein, or in contiguous veins, while these metals also very commonly occur together in the same veins."*

Following up these conceptions and discoveries of Mr. Fox, we subjoin the following from the "*Literary Gazette*:"

The editors of that periodical say—

"Mr. Fox has for some time—and hitherto very successfully—turned his attention to the formation of mineral bodies or veins; and to the principle of electro-magnetism, as applied to these formations. It had been observed by him, and by others acquainted with the peculiar structure of the Cornish metalliferous deposits, that the same lode would sometimes contain copper pyrites; and within a short distance, and merely separated by the common argil-

* Bridgewater Treatise, vol. ii. pp. 108—110.

laceous substances, sulphate of copper, or some other modification of the same material. Whenever this occurred, the lode was generally found to be saturated with water, containing various salts; a circumstance that seems to influence in some degree the change in the mineral deposit. Mr. Fox, applying the exercise of his strong and highly cultivated mind to these phenomena, immediately conceived the notion that electro-magnetism was the prime agent in the production of this extraordinary change. To prove this, he procured an earthern pan, which he divided into two compartments, by inserting in the centre a barrier of clay, saturated with dilute sulphuric acid, and jammed down closely. In the one compartment he placed water, charged with the sulphate of copper; and in the other, dilute sulphuric acid. In the sulphuric acid he placed plates of zinc, connected with a rod and wire with a piece of copper pyrites, suspended in the water contained in the other compartment. In a short time, electro-magnetism commenced. The sulphur passed from the water, through the barrier of clay to the zinc, and there not being sufficient sulphur in that water to form, by this union, sulphate of zinc, the copper pyrites was deprived of a portion of its sulphur, and changed to common grey copper! Mr. Fox thinks he shall be enabled to complete this experiment without the dilute sulphuric acid, and merely by water."*

M. de la Beche, when treating on this prolific matter, says,

"To enter fully into the subject *of the occurrence of metals in rocks* would require a volume; the following notice is, therefore, solely intended to call the attention to a few circumstances which may be generally interesting:—

"Metals occur in rocks either disseminated; in bunches; in a network of strings or small veins; in beds; or in veins filling fissures, which traverse beds or masses of rock. . . . . .

"The most common occurrence of metals is, however, in veins, or, as they are termed in Cornwall, *lodes*. These are in part filled up, but in various proportions, with metallic substances, and have the general appearance of fissures. They dip at various angles, not unfrequently approaching a vertical position. It was at one time much disputed whether these fissures had been filled from above or beneath; but from facts that have been noticed within a few years, more particularly by Mr. Taylor and Mr. Carne, there is much diffi-

* Literary Gazette of 3rd May, 1836, p. 296.

culty in considering that either hypothesis is generally correct. It now appears that the mineral character of a metalliferous vein greatly depends upon the rock which it traverses; that is, when a vein traverses two rocks, as, for instance, granite and slate, the contents of the vein are not, generally, the same in the two rocks, but will be different in the one and the other." . . . . .

"This fact of the alteration of metallic veins in their passage from one kind of rock to another, or in the same rock, should that become changed, would lead us to consider, with Mr. Fox, that their formation has been, in a great measure, due to the silent though powerful influence of electricity. This enquiry may yet be considered in its infancy; but the experiments of Mr. Fox on the electro-magnetic properties of the metalliferous veins of Cornwall will be read with great interest.

"Mr. Fox considers that the relative power of conducting galvanic electricity is in the following order in some of the metalliferous minerals. *Conductors*—Copper, nickel, purple copper, yellow sulphuret of copper, vitrious copper, sulphuret of iron, arsenical pyrites, sulphuret of lead, arsenical cobalt, crystallized black oxide of manganese, Tennantite, Fahlerz. *Very imperfect conductors*—Sulphuret of molybdenum, sulphuret of tin, or rather bell-metal ore. *Non-conductors*—Sulphuret of silver, sulphuret of mercury, sulphuret of antimony, sulphuret of bismuth, cupriferous bismuth, realgar, sulphuret of manganese, sulphuret of zinc, and mineral combinations of metals, with oxygen and with acids." (Phil. Trans., 1830, p. 399.)

And finally from M. de la Beche—

"As the information at present stands, the history of metalliferous veins is anything but clear. It is quite certain, from the dissemination of metals in rocks, that they may constitute an original portion of them; the small strings, also, which cross each other, and are unconnected with great veins, have all the appearance of chemical separations from the including rock; therefore a given rock may contain the necessary elements for secreting substances into a fissure in the same manner that carbonate of lime frequently fills fissures in limestones, and quartzose veins are common in rocks where silex is abundant."*

Professor Phillips thus expresses himself on this new and interesting branch of geological research—

* Manual, pp. 521—524.

"One might venture to say there is a peculiar electric attraction between sulphuret of lead and limestone rock; and this idea, followed so far, leads to the doctrine of the metallic contents being secreted from the bordering rocks. The materials of the veins seem indeed, in many instances, to have been transferred by electric currents through solid substances, but they are really diffused *from* the veins into the cavities of the neighbouring rocks, not collected from these *into* the vein fissures."

And at another place he says—

"The first notions *on the direction of convulsive movements* were formed by miners, who observed as a fact of great practical importance to their art, that the mineral veins which were most generally and uniformly productive ranged *east* and *west*, or nearly; and that these *right running* veins were divided by *cross-courses*, passing *north* and *south*, or nearly. Not that there are no other directions of veins and cross-courses, but amidst many directions these prevail. Cornwall, Wales, Cumberland, the Penine limestone region, Brittany, the Hartz, the Hungarian mines, and even Mexico, appear to confirm this law, suggested by practical men. It is very difficult, or, rather impossible, to explain it; but we may remark, that in many cases, the direction of mineral veins follows that of the natural joints and fissures produced by consolidation of the rocks; and that it is very conceivable that electrical currents, or other polarizing agents, might communicate to such fissures one or more definite directions. In fact, it is proved that, in Yorkshire, Derbyshire, and other large tracts, these fissures have definite directions, mostly rectangular to one another." . . . . .

And again—

"The *origin of mineral veins* has long been, and will for some time continue, a disputable question in geology; but considerable progress has been made in it since the days of Werner and Playfair. *The origin of the fissures*, in which a great proportion of mineral veins occur, is certainly proved to be either by molecular attraction, causing contraction of the mass of rocks, and thus generating joints or divisional planes, or by the tension of elevatory forces, as explained in the last section.

". . . . . *Repletion of mineral veins.*—The opinion of the Cornish miners and geologists generally appears to be, that most all of these

veins are to be regarded as contemporaneous with the rocks which enclose them.

". . . . . Whatever force may be thought due to the facts and the opinions brought forward on the subject of veins in Cornwall, it is perfectly certain, that in distinctly stratified countries, the mineral matter has been introduced into open fissures long after the deposition and consolidation of the strata. *The proof is unanswerable.* Joints and fissures filled with metallic and sparry matters (mineral veins), pass through rocks which are not contemporaneous but successively deposited, and *divide corals, fishes, &c.* It is evident that this must close the discussion as far as regards these rocks. But though it cannot be reasonably doubted, as a general truth, that the vein-stuff has been transferred into open fissures of the rocks, it is not so easy to determine how this was effected. Have the materials been injected from below as lavas into the fissures of a mountain (Hutton), or sublimed from a hot region to a cold fissure (Buckland), or segregated by some peculiar influence from the neighbouring rocks (Sedgwick), or poured into them in aqueous solution (Werner), or transferred by electrical currents (Fox), as in some instances we have good reason to believe?

"In the present state of our knowledge neither of these results can be admitted exclusively, yet, perhaps, none ought to be absolutely rejected as a cause of the repletion of metalliferous fissures."

And in conclusion from Mr. Phillips—

"As a general result we cannot doubt of the far greater prevalence of mineral veins in the older than in the newer rocks. Not one case is known of a mineral vein being at any time worked in any part of the British islands above the new red sandstone. In the new red sandstone and magnesian limestone, hardly more than slight traces of such products occur; they are rare in our coal tracts, but they become abundant in the mountain limestone and older strata. But yet it is probable that this relation of mineral veins to the age of deposits is merely a consequence of the more general truth that their origin is from below, that the fissures which they occupy, and the metallic and sparry matters which compose them, are more numerous near the igneous rocks, which, in so many instances, form the axes of movement."*

* Treatise, pp. 262, 263, 270—273, 275.

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXIV.

Recapitulation of points established in the preceding Chapter. Conclusions to be drawn from the oblique direction of metallic veins: various means by which their contents may have been lodged in them. Thermo-electricity that which most probably was employed. Proofs in favour of this assumption, and the manifold evidences of beneficent design in the formation, and in the location of metallic veins. Geological testimonies of the existence of amorphous rocks, capable of having occasioned the electrical currents, and other phenomena from which these metalliferous veins originate. Granitic Rocks: their genera, position, and their relation to associated and superincumbent formations. Enquiry into their supposed origin with respect to the internal structure of the Earth, and the assistance which the Dynamical Theory affords, by simplifying this difficult question.

The mind having been prepared by the extracts and the opinions which have been given in the preceding chapter, let us now endeavour, if we can, to come to some conclusion which may assist in eventually leading to the truth. Towards the solution of this difficult problem, we are already furnished with a considerable amount of data to enable us to proceed more satisfactorily with our work; we shall take the liberty of recapitulating them. Firstly, then. We know the *direction* of the veins; secondly. We know their *contents*, and the contents of the cross courses; thirdly. We know their *relative geological positions*, and that they do not cause faults or dislocations amongst the formations through which they pass; Fourthly. We are convinced that a *force* of some kind sufficient to have caused their formation, and especially their *direction* must have

been employed; and, lastly. We know the nature and direction of *all forces*. Therefore, by the application of the differential method of reasoning we may perhaps discover *that* which was employed by the Creator, as the secondary cause, in forming the metallic veins.

From the perpendicular direction in which *mineral* veins proceed towards the surface, it has been shown, in treating of them, that they owe their origin to a combination of the centrifugal impetus occasioned by the rotation of the earth around its axis, and to the heat which was engendered thereby, especially at the axes of elevation; and if we contrast this with the *oblique* direction in which *metallic* veins proceed to the same point, we shall be at once convinced, *that these latter cannot have emanated from the same cause which produced the others:* unless, indeed, we should imagine, that unlike any other force, it could have simultaneously given birth to two sets of veins proceeding in different directions. We may, therefore, discard the centrifugal impetus as not being the *immediate cause* of the direction of the metalliferous veins; and in this manner dispose of one of the known forces.

Neither could the *oblique direction* of these veins result from a composition of forces, between that engendered by centrifugal impetus towards the circumference, and a tangential force at right angles thereto: because, though this might account for some of these diagonal lines, it completely fails when applied to those which *cut the others at right angles;* and, therefore, we may safely dismiss this also as not having been the immediate cause of the fissures in question.

With regard to *infiltration from without*, we may dispose of it in the same manner. For, although it is probable it may have been the means of supplying the external fissures—when once they were made—with mineral and metallic solutions, *it could not have caused the fissures themselves;* both on account of its inadequacy as well as the oblique direction in which these proceed. A liquid, if it could by any possibility have so penetrated as to have caused fissures in solid rock, would, by the laws governing its motion, have done so in lines perpendicular to the earth's surface. We may, therefore, eliminate this cause of origin also from the catalogue. Consequently,

the disposal of those forces, restricts us to the only remaining power at all capable of producing these metallic veins, namely, *some one of the various modifications of electrical agency;* a conclusion, which not only agrees with Mr. Fox's conceptions and experiments; but likewise harmonises with the results of geological research amongst the formations where these veins abound. The particular kind of electricity which seems best to accord with what has been observed, is that called *Thermo-electricity;** and, in consequence, after relating some particulars regarding its discovery and its manner of acting, we shall endeavour to apply it to the case in question and show its sufficiency.

"It has already been observed," says the author of the Connexion of the Sciences, "that three bodies are requisite to form a galvanic circuit, one of which must be a fluid. But in 1822, Prof. Seebeck, of Berlin, discovered that electric currents may be produced by the partial application of heat to a circuit formed of two solid conductors. For example, when a semi-circle of bismuth, joined to a semi-circle of antimony, so as to form a ring, is heated at one of the junctions by a lamp, a current of electricity flows through the circuit from the antimony to the bismuth, and such thermo-electric currents produce all the electro-magnetic effects. . . . . . M. Nobili observed that in all metals, except zinc, iron, and antimony, the electricity flows from the hot part towards that which is cold. That philosopher attributes terrestrial magnetism to a difference in the action of heat on the various substances of which the crust of the earth is composed; and in confirmation of his views he has produced electrical currents by the contact of two pieces of moist clay, of which one was hotter than the other.

"M. Bequerel constructed a thermo-electric battery of one kind of metal, by which he has determined the relation between the heat employed, and the intensity of the resulting electricity. He found that in most metals the intensity of the current increases with the heat to a certain limit, but that this law extends much farther in metals which are difficult to fuse, and which do not rust. The experiments of Professor Cumming show, that the mutual action of a magnet and a thermo-electric current is subject to the same laws as those of magnets and galvanic currents, consequently all the pheno-

* Theorems 59 to 66.

mena of repulsions, attraction, and rotation, may be exhibited by a thermo-electric current."

And at another place this author observes—

" Dr. Faraday has proved by recent experiments on bodies, both in solution and fusion, that electrical affinity is merely a result of the electrical state of the particles of matter."*

"If the theory of internal heat," says M. de la Beche, with his usual circumspection, "be well founded, it will be evident that the two ends of a metallic vein will be differently heated, and therefore we should have a thermo-electrical apparatus on a large scale, producing effects which, though slow, might be very considerable. How far such really exists in nature remains questionable, but it may be observed that the experiments of Mr. W. Fox show the possibility of their occurrence; and should further researches in this highly interesting subject so divide it, that some of its present apparent complexity may disappear, a great advance will be made in this now obscure branch of geological enquiry."†

Professor Playfair, with his characteristic acumen, refutes the Neptunian while he vindicates the Plutonic hypothesis, as far as the formation of metals in veins is concerned, in the following conclusive passage of his Illustrations—

"The state in which gold and silver are often found pervading masses of quartz, and shooting across them in every direction," he remarks, " furnishes a strong argument for the igneous origin both of the metal and the stone. From such specimens it is evident, that the quartz and the metal crystallized, or passed from a fluid to a solid state, at the same time: and it is hardly less clear, that this fluidity did not proceed from solution in any menstruum: for the menstruum, whether water or the *chaotic fluid*, to enable it to dissolve the quartz, must have had an alkaline impregnation; and to enable it to dissolve the metal, it must have had, at the same time, an acid impregnation. But these two opposite qualities could not reside in the same subject; the acid and the alkali would unite together, and, if equally powerful, form a neutral salt, like sea salt, incapable of acting either on the metallic or the siliceous body. If the acid was

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* Mrs. Somerville on the Connexion of the Sciences, pp. 345, 346, 123.

† Manual, p. 524.

most powerful, the compound salt might act on the metal, but not at all upon the quartz; and if the alkali was most powerful, the compound might act on the quartz, but not at all on the metal. In no case, therefore, could it act on both at the same time. Fire or heat, if sufficiently intense, is not subject to this difficulty, as it could exercise its force with equal effect on both bodies."*

And in further confirmation of this particular point, we beg reference to the very conclusive evidence given at page 99, from Mr. Lyell's Elements, which, in consequence of having been so recently quoted, we do not here repeat.†

What has now been adduced sufficiently proves, that heat, when applied to distinct mineral substances—unequal conductors—puts those associated materials into a condition proper for eliciting currents of thermo-electricity; while, what has previously been established, leaves as little doubt on the mind, that during the first rotation of the earth around its axis, there was sufficient heat evolved to act as a *primum mobile* in this case, and to set those dormant currents into active operation. And if, to this, we add the corroborative consideration that the strata, at the period when these operations are supposed to have taken place, were impregnated with metallic depositions in combination with other elements, agreeing precisely with those discovered in metallic veins, we shall be convinced, that according to the wise and beneficent ordinations of the Creator, all the requisites were amply prepared for the event; so that the thermo-electrical currents, when put into exercise, had wherewithal to operate upon, and to produce, with due separation, either by sublimation, or rapid segregation, those stores of metallic riches, destined to be transmuted for the use—not for the abuse—of man.

If a view be taken of any sectional geological map, and, at the same time, it be remembered, that "the granite and Killas—the intruded masses of more recent granite—and the various kinds of porphyritic rocks, called Elvans, are considered to have occupied their present relative positions before the origin of the fissures, forming the metalliferous veins which

* Illustrations of the Huttonian Theory, vol. i. pp. 249, 250.

† Elements of Geology, vol ii. p. 343.

intersect them all,"* we must come to the final conclusion, that they were, in fact, formed *after* these mineral masses assumed their present positions; because *the fissures or veins pass indiscriminately, and almost in straight lines, through the whole.*† Consequently, they originated when the heat and electrical influences, occasioned by the friction arising from the movement amongst these masses, were at their maximum; that is, *towards the conclusion of the first day's rotation of the earth around its axis.* That this *was the period of their formation* must appear obvious when we consider, in the first instance, that they could not have existed *before*, because the general movement which ensued amongst the rocks of the earth's crust when its rotation took place, would have completely deranged their lines of junction, had they been formed when, as yet, these rocks lay in a horizontal position; and, in the next, we know of no event posterior thereto sufficient to have produced them; while, in what *then* occurred, there were causes put in operation, according to the thermo-electric theory, sufficient to have done so.

The arguments opposed to the supposition—that these fissures originated in a shrinking of the rocks—amount almost to demonstration. For, although fissures from contraction, when a mineral which has been heated begins to cool, is perfectly supposable in the case of one homogenous mass, it is quite inadmissible should we think of applying it to the case in question, in which the fissures pass in straight lines indiscriminately through granite, trap, porphyry, greenstone, gneiss, grauwacke, limestone, and all other descriptions of clay, or aluminous formations; it being scarcely possible to conceive that one and the same degree of heat could have produced so equal an effect on substances differing so materially in their nature and relation for heat, and, more especially, those of aluminous composition, which, unlike the other associated masses, so far from *expanding* on the application of heat, are found to *contract*. But none of these difficulties exist, when we attribute the

* Professor Buckland's Bridgewater Treatise, vol. ii. p. 108.

† In confirmation of this, see especially a passage in Phillips's Treatise, p. 272, on the authority of *Rep. Brit. Association*, Edinburgh meeting

result to the agency of thermo-electricity; all the requisites for its evolution were present; and when emanating from such centres of heat as the nucleii of mountain chains or axes of disturbance, it must have been sufficient to have overcome every barrier; whilst the electrical influence, in proceeding "from the heated parts towards those which were cold," would pursue the very direction in which these metallic veins are found to run, *provided they emanated when the mountains were at their highest elevation;* which agreeing, likewise, with the period of the maximum of heat, fulfils all the conditions of the problem; *and fixes the era of their formation with unlooked-for precision.*

With infinite pleasure we refer to the interesting observations made by Professor Buckland, and others mentioned by him, with regard to the evidences afforded of wise and beneficent design for the well being of man, in the manner in which both the precious and the useful metals have been deposited in lodes or veins.* What has been said is true, and evinces alike the constant presence and agency of an ever watchful Providence over all that concerns us, and demonstrates, in the clearest manner, the wisdom, prescience, and goodness of God; and while we feel grateful towards him, who is the source of all our blessings and our enjoyments, we hasten to bring forward another instance of great consideration for man's welfare, which is manifested by the *direction* which these metallic veins were made to take amongst the mineral masses where they exist.

Had they, like the *mineral* veins, been under the influence of the centrifugal impetus—emanating as they did from the nucleii of mountain chains, *after* these reached their highest elevations—they would, in most cases, have had not only a longer course to run in order to reach the surface, but would have made their appearance upon the scarped, arid, and uninhabitable summits and shoulders of these primary masses, whose bare and rugged surfaces would have rendered them almost inaccessible, and scarcely capable of having been wrought. They would also have been much more concentrated; and, consequently, less equally divided amongst the world's in-

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* Bridgewater Treatise.

habitants. Besides all these inconveniences, it is more than probable, that had they merely obeyed the laws of centrifugal force, and had commenced their course, as they evidently have done, *after* the formation of all the mineral veins and dykes, they would not have had impetus sufficient to have perforated them, but would have been embarrassed, "nipped," if not entirely interrupted in their way to the surface. All these inconveniences and impediments, however, have not only been completely avoided and overcome by that wisdom which foreseeth all things, but they are transformed into positive benefits, by their having been caused to emanate from the irresistible power of thermo-electricity, and to shoot forth, not before, but *after*, the elevation of the mountains in which they abound. Born of this subtile influence, they were not only enabled to pass unresistingly through every obstacle, *but likewise to follow the most direct route to the surface;* while by their eruption, until the earth had assumed its actual form, that *direction* was so disposed as to occasion their spreading over an extent of country, which—though not the most fertile—is at least incomparably better than the rugged peaks amongst which they would, otherwise, have abounded. And, even the circumstance of these metallic treasures being conferred on countries not the most fertile in vegetable productions, in consequence of their geological position and agricultural character, evinces a true parental foresight and benevolence of design, together with a just impartiality towards the world's inhabitants, who all, alike, are the children of the same Creator.

This idea is so admirably brought out in the passage to which we have alluded, that we feel ourselves constrained to insert it:—

"Whatever may have been the means," observes Dr. Buckland, "whereby mineral veins were charged with their precious contents; whether segregation or sublimation was the *exclusive* method by which the metals were accumulated; or whether each of the supposed causes may have operated simultaneously or consecutively in their production; the existence of these veins remains a fact of the highest importance to the human race; and although the disturbances, and other processes in which they originated, may have taken place at periods long antecedent to the creation of our species, we

may reasonably infer that a provision for the comfort and convenience of the last and most perfect creatures he was about to place upon its surface, was in the providential contemplation of the Creator, in his primary disposal of the physical forces, which have caused some of the earliest and most violent perturbations of the globe."*

To conclude these detailed investigations into the diversified phenomena attendant on the elevation of mountain chains, accompanied by the forcible injection, through the centrifugal impetus, of enormous masses of unstratified rock, all that is wanting is, to enquire, *whether geologists recognise a mineral, of such a character and general prevalence, as may warrant our relying, with implicit confidence, on the inferences which have been drawn from its supposed existence?* To do this we shall refer in succession, to the *twentieth*, *twenty-third*, and *twenty-fifth* Theorems, in all of which that point is more or less elicited; while we direct the attention, for the present, to the last of these, in which it is stated, "*That granite is found to be essentially the same wherever it hitherto has been examined. That it is in the deeper regions of the globe, where granite has its origin, that that of trap must also be looked for. That whatever difference may exist between these rocks, whether in their relation to the strata or their mineralogical character, they are remarkably analogous in almost every important general circumstance.*

And that there is good reason even for considering that granite, porphyry, and trap have had a common origin.

The principal evidences on which that opinion is founded are the following:—

"The term granite," observes Professor Playfair, "is used by Dr. Hutton to signify an aggregate stone, in which quartz, felspar, and mica are found distinct from one another, and not dispersed in layers. The addition of hornblende, schorl, or garnet, to the three ingredients just mentioned, is not understood to alter the *genus* of the stone, but only to constitute a specific difference, which it is the business of lithology to mark by some appropriate character, annexed to the generic name of granite. . . . . .

* Bridgewater Treatise, vol. i. pp. 554, 555.

"One ingredient which is essential to granite, namely, quartz, is not contained in whinstone; and this circumstance serves to distinguish these *genera* from one another, though in other respects, they seem to be united by a chain of insensible gradations, from the most homogeneous basalts, to granite the most highly crystalline."*

"Assuming," says Dr. Buckland, in a passage already quoted, "that fire and water have been the two great agents employed in reducing the surface of the globe to its actual condition, we see in repeated operations of these agents, causes adequate to the production of these irregular elevations and depressions of the fundamental rocks of the granitic series, which are delineated in the lower region of our section, as forming the basis of the entire superstructure of stratified rocks."

At another part of his work, when tracing the origin of volcanic rocks, basalt and trap dykes, he adds—

"As the mineral characters of these dykes present insensible gradations, from a state of compact lava, through infinite varieties of greenstone, serpentine, and porphyry, to granite, we refer them all to a common igneous origin."†

"Such are the rocks," says M. de la Beche, "namely—*granite, porphyry, diallage, serpentine, basalt, greenstone*, and other rocks, usually termed *trappean; claystone, clinkstone, &c.*, commonly called unstratified. It will have been seen that they so pass into one another, that distinctions are not easily established between them. Mineralogical granite passes through various stages, and graduates into the compounds named greenstone, and others of the trappean class. . . . . .

Again—

"The trappean rocks, though there is much difficulty in separating them from the granitic, may for convenience be considered separately from them."

Further on he says—

"The above is sufficient to show, that trap, under certain conditions, may pass into serpentine. . . . . The serpentine and diallage rocks of Liguria are particularly instructive, as they appear

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* Illustrations of the Huttonian Theory, pp. 95, 96.

† Bridgewater Treatise, vol. i. p. 48, and vol. ii. p. 3.

under a variety of forms, and seem to be connected with the disturbance of the strata in that country."

And in conclusion from this geologist—

"If we regard these various igneous products as a matter which has successively, and during the lapse of all that time comprehended between the earliest formation of the stratified rocks and the present day, been ejected from the interior of the earth, we shall be struck with certain differences of these rocks on the great scale, which has led to their practical arrangement under the heads of granitic, trappean, serpentinous, and volcanic products as above noticed. . . . . . As yet we are unacquainted with the conditions necessary for the production of these different compounds. . . . . . Possibly the quantity and proportion of the elementary substances might not vary as much as we might, from the general mineral character alone, be led to expect, but at first sight we may imagine that silica predominated more in the granitic rocks than in the others, while magnesia abounded in those parts of the earth which vomited forth the serpentinous deposits."*

"The plutonic rocks," observes Mr. Lyell, "may be treated of next in order, as they are most nearly allied to the volcanic class already considered. . . . . . By some writers, all the rocks now under consideration have been comprehended under the name of granite, which is then understood to embrace a large family of crystalline and compound rocks, usually found underlying all other formations; whereas we have seen that trap very commonly overlies strata of different ages. . . . . . Although it is the general peculiarity of granite to assume no definite shape, it is, nevertheless, occasionally subdivided by fissures, so as to assume a cuboidal and even a columnar structure. . . . . .

"Felspar, quartz, and mica are usually considered as the minerals essential to granite, the felspar being most abundant in quantity, and the proportion of quartz exceeding that of mica. . . . . . *Porphyritic granite.*—This name has been sometimes given to that variety in which large crystals of felspar, sometimes more than an inch in length, are scattered through an ordinary base of granite. . . . . . *Syenite.*—When hornblende is the substitute for mica, which is very commonly the case, the rock becomes syenite: so

* Manual of Geology, pp. 486—489, 493, 498, 500.

called from the celebrated ancient quarries of Syene, in Egypt. It has all the appearance of ordinary granite, except when mineralogically examined in hand specimens, and is fully entitled to rank as a geological member of the same plutonic family as granite. . . . . . *Syenitic-granite.*—The quadruple compound of quartz, felspar, mica, and hornblende, may be so termed. This rock occurs in Scotland and in Guernsey. *Talcose granite*, or Protogine of the French, is a mixture of felspar, quartz, and talc. It abounds in the Alps, and in some parts of Cornwall. . . . . . *Schorl rock and schorly granite.*—The former of these is an aggregate of schorl, or tourmaline, and quartz. When felspar and mica are also present, it may be called schorly granite. This kind of granite is comparatively rare. *Eurite.*—A rock in which all the ingredients of granite are blended into a finely granular mass. Crystals of quartz and mica are sometimes scattered through the base of Eurite. *Pegmatite*, a name given by French writers to a variety of granite; a granular mixture of quartz and felspar; frequent in granite veins, passes into graphic granite. All these granites pass into certain kinds of trap, a circumstance which affords one of many arguments in favour of what is now the prevailing opinion, that the granites are also of igneous origin.

"It has been already hinted, that the heat, which in every active volcano extends downwards to indefinite depths, must produce simultaneously very different effects near the surface, and far below it; and we cannot suppose that rocks resulting from crystallizing or fused matter under a pressure of several miles of the earth's crust can resemble those formed at or near the surface. Hence the production at great depths of a class of rocks analogous to the volcanic, yet differing in many particulars, might almost have been predicted, even had we no plutonic formations to account for. How well these agree, both in their positive and negative characters, with the theory of their deep subterranean origin, the student will be able to judge by considering the descriptions already given.

"It has, however, been objected, that if the granitic and volcanic rocks were simply different parts of one great series, we ought to find in mountain chains volcanic dykes passing upwards into lava, and downwards into granite. But we may answer, that our vertical sections are usually of small extent; and if we find in certain places a transition from trap to porous lava, and in others a passage from granite to trap, it is as much as could be expected of this evidence.

"Granites," continues Mr. Lyell, "pass into certain kinds of trap,

a circumstance which affords one of many arguments in favour of what is now the prevailing opinion, that the granites are also of igneous origin. The contrast of the most crystalline form of granite, with that of the most common and earthy trap, is undoubtedly great; but each member of the volcanic class is capable of becoming porphyritic, and the base of the porphyry may be more and more crystalline, until the mass passes to the kind of granite most nearly allied in mineral composition.

"The minerals which constitute alike the granitic and volcanic rocks, consist, almost exclusively, of seven elements, namely—silica, alumina, magnesia, lime, soda, potash, and iron; and these may sometimes exist in about the same proportions in a porous lava, a compact trap, or a crystalline granite, ... and, finally, it would be easy to multiply examples and authorities to prove the gradation of the granitic into the trap rocks."*

The following corroborative extracts are from Professor Phillips's Treatise:—

"Few parts of the globe, except some of the vast plains and deserts, are entirely deficient of rocks which are not stratified, though the surface which they occupy is not nearly so great as that covered by the strata. Granitic and basaltic rocks compose generally the greater portion of the unstratified masses, as in Britain, and lie in the same relations to the strata. For granitic rocks throughout the globe, are the most frequent axes or centres of mountain groups, and basaltic rocks fill dykes and spread in irregular cappings over the strata. It is evident, therefore, that the structure of the exterior parts of the globe, though full of local diversity, is all formed upon one general plan, and produced by similar agencies."

And again—

"*Igneous rock-veins.*—Besides the irregular granitic floor upon which all the gneiss and mica-slate system rests, and from which at many points, veins or interspersed beds pass up into these strata, many other masses of pyrogenous rock have been forced among the gneiss and mica-slate, so as to constitute dykes or irregular masses of large extent. Thus porphyry, greenstone, basalt, and other crystallized rocks are found mixed with the gneiss and mica-slate in

* Elements of Geology, vol ii. pp. 324—348.

various parts of the Highlands, Hebrides, and Zetland. Of these the most frequent is porphyry."

And in continuation—

"The state of the globe during the period of the production of the primary strata may never be fully disclosed by geological inquiries, aided by higher departments of knowledge: yet, as a view of the successive conditions of the globe, however imperfect, constitutes the very essence of phylosophical geology, it is necessary to ascertain what progress has been made in this dark research, into some of the earliest natural records of creation. It is remarkable that the lowest of all the known systems of stratified deposits should be at once the most extensive, the most nearly universal, the most uniform in mineral character, the only one from which organic life appears to be totally excluded, and in which the character of mechanical aggregation is the most obscure. . . . . .

"In accordance with the undoubted truth of the general expansion of rocks of igneous origin, below all the stratified masses, we naturally inquire if the agency of subterranean heat is of a kind to account for the phenomena observed."*

In further corroboration of this point, we beg to refer, particularly, to a very neat and comprehensive passage from Professor Phillips's Treatise on Geology,† which we have already had occasion to adduce, in evidence, on a kindred subject; and which bears very conclusively on that now under discussion:—

"The reasons," says Dr. M'Culloch, "for believing that all the unstratified rocks are alike of igneous origin, or that they are substances crystallized from a fluid of fusion, will be given in a more proper place hereafter. . . . . . As it is apparent that granite has been in a state of fluidity beneath the strata, and that, during this state, these have been elevated in an irregular manner, it is easy to account for the irregularity of its general surface, or for the partial way in which it is found distributed on the earth's superfices. The consequence of the unequal elevation of the strata was to produce those interior inequalities that have been filled by the yielding mass which was the immediate cause of that fracture, and the concomitant

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* Treatise, pp. 42, 78, 79, 93, 94.

† Pages 68, 69. Also p. 313 of this work.

of the force exerted. The production of the veins is another obvious consequence of the fractures or discontinuities formed by the displacements of the strata. It must be remembered here, however, that the actual appearance of granite at the surface of the earth is, in most cases, the consequence of another train of effects, consisting in the waste of those parts of the strata by which it was once covered; a waste of which the whole globe produces the most unquestionable evidence. From the progressive state of that waste, it follows, that the apparent quantity of granite must be constantly increasing, although itself is subject to decay; and if it really be the basis of all the stratified rocks, it is possible to conceive that the earth might, at some future day, contain granite only in its more elevated portions; while this could not happen, of course, at low elevations, or near the level of the sea, because here the ordinary causes of each cease to act.

"Since now the other division of the unstratified rocks is found above the strata rather than below, it is necessary to inquire respecting its source of origin. That it was produced in a fluid state, and consolidated from that condition, rests on precisely the same grounds as the case of granite. The nature of the different substances is similar, often identical, the effects are the same on the including strata, and the disposition of the veins is strictly analogous, varying only according to circumstances which have already been stated. Nor is trap exclusively superficial, since it is actually found beneath the strata in considerable masses, or else in such a relative position to them vertically as to resemble granite in this respect; while it will be further shown hereafter, that many of the extensive masses of those rocks now visible at the surface, have actually been once covered by strata which have disappeared in the progress of decay. . . . . . By the argument of dilemma, therefore, we must seek their origin in the same regions that produced granite. That this really is their origin, is further proved by the positive arguments derived from the masses that lie beneath, or among the strata, by the depth and magnitude of their veins, and by the marks of force which accompany their juxta-position to the strata. . . . . . It is in the deeper regions of the globe, therefore, in those where we have found the origin of granite, that we must seek that of trap. These substances are essentially of the same nature, but they have been produced at distant periods of time. . . . . . It must thus be apparent, that whatever differences may exist between trap and granite, whether in their relations to the strata, or their mineral

characters, they are strikingly analogous in almost every essential general circumstance, and that the former may, in a certain sense, be considered as a recent granite; as the granite of the newer strata. . . . . . Thus it is proved that granite, or at least a rock originating in the same causes, may possess the characters of some of the most common varieties of the most recent traps. It remains to reverse the proposition, and to adduce instances of the granitic character among the recent unstratified rocks. . . . . .

"In the meantime I am unable to perceive that anything is wanting to prove the identity of origin in trap and granite. It is little likely, at least, that geology will often furnish us with evidence of a more decided nature. Nor is it an indispensable requisite to this argument, to produce numerous examples; since there are innumerable cases in science, among which this seems one, where one or two facts are as decisive as a hundred."*

At another place he says—

"Hence it also is, that rocks preserve the same characters wherever they occur, a circumstance otherwise calculated to excite our surprise. In every other department of nature, her productions vary according to the climate and situation, but granite is the same in Egypt and in Greenland."

And again, still further on, he adds—

"In examining the revolution of the earth, I have rendered it probable, that there has been granite, or an analogous substance, prior to all strata, and the original source of the whole."†

Professor Playfair states—

"Granite, the fossil now defined, exists, like whinstone and porphyry, both in masses and in veins, though most frequently in the former. It is, like them, unstratified in its texture, and is regarded here, as being also unstratified in its outward structure.‡

"Granite, it has been just said, exists most commonly in masses; and these masses are rarely, if ever, incumbent on any other rock:

* Geology, by Dr. M'Culloch, vol. i. pp. 145—160. It is recommended that the reader should refer to the work itself, and peruse the whole chapter, which could not be given any fuller here, although replete with interest.

† Geology, by Dr. M'Culloch, vol. ii. p 196.

‡ Ibid, pp. 87, 88.

they are the bases on which others rest, and seem, for the most part, to rise up from under the ancient or primary strata. The granite, therefore, wherever it is found, is inferior to every other rock, and as it also composes many of the greatest mountains, it has the peculiarity of being elevated the highest into the atmosphere, and sunk the deepest under the surface, of all the mineral substances with which we are acquainted."*

With these copious extracts we shall conclude the evidence, in favour of the acknowledged existence of an amorphous mass of mineral matter beneath all those formations which retain their stratified texture; and, likewise, in testimony of the diversified effects—shown by phenomena appreciable by the senses—which resulted from the general convulsion that took place amongst those parts of the earth's crust, when it was caused to revolve around its axis, by the formation of the light and its division from the darkness, on the first day of the Mosaic week. This act of protorotation, as we have so repeatedly inculcated, having, by its centrifugal impetus, produced the universal movement above alluded to, which, in turn, caused the friction and consequent fierce heat which fused the mineral substances; and fitted them, in this condition, for irresistible protrusion into the rents, fissures, and centres of mountains and mountain chains, arising from the extension and breaking up of the earth's surface, to complete its static form of revolution; while the same centrifugal impetus, and the heat thus engendered, co-operated to impel these melted streams into those diversified apertures of enlargement, by which alone they could find vent, and where alone they were required! Thus exhibiting another fine example of a complete chain of cause and effect, which links the external form, peculiar position, and internal structure of these rocks of igneous origin, to the creation of the light and its division from the darkness.

Thus far the Dynamical Theory leads us successfully in our endeavours to account for the earth's formation; but when we attempt to apply it, to ascertain the probable condition of these mineral ingredients, before they were made to issue forth,

* Playfair's Works, vol. i. pp. 95—97.

in universal streams, from almost every point of the globe, to insinuate and wedge themselves into the openings prepared for them, when it pleased the Creator so to arrange it; when we make this application of our theory, we are reminded, that it has more to do with *what is*, than with what *was;* and that it can assist us only to infer the original condition of these hidden masses—hidden far beneath the accumulated deposits of the non-rotatory period—by the transformation which the dynamical forces have effected in them.

Perhaps, indeed, the greatest benefit which can be derived from our present labours, in relation to this particular subject, will be to direct us to seek, in the movement, friction, heat, and centrifugal impetus—the inseparable concomitants of the Dynamic Theory—for the true cause of the difference between stratified and unstratified rocks, and every diversified feature of these two great classes.

But even this points onwards, not backwards, and leaves the chief difficulty untouched. We still recognise the necessity of supposing the existence of some universal substratum, on which deposition first began, and which possessed more cohesion than would be produced by mere juxta-position of particles, such as sand, for it had to receive the deposits from the primitive ocean, which now constitute the strata; and to sustain them for countless ages upon its bosom. While, on the other hand, we are forced to confess, that the particles of this substratum must have had sufficient mobility to have admitted of their being put in motion, and of their conducting themselves in all respects as a semi-fluid or ductile mass, even before they had been reduced to that state by the heat resulting from friction; for this could only *follow*, but could not *precede* their motion; while, to add to our difficulty, their present crystallized texture forbids the supposition of partial previous fluidity having been produced by water; for if this had been the case, its subsequent evaporation, when driven off in the process of crystallization, would, we are inclined to think, have left these primitive rocks much more porous than they really are.

Indeed, the more we reflect on all the phenomena attending the elevation of continental ridges, and the depression of

oceanic hollows, which seem to reveal to us a state of mysterious elasticity in the internal regions of our globe, and consider at the same time, the scrupulous economy of means to the ends everywhere observable in the works of the Creator, while we are under the conviction, that our planet, like all the other heavenly bodies, is destined to be a pedestal to *uphold upon its surface*, not a receptacle for containing *within*. And when we contrast all these motives for a hollow or cavernous structure, with the apparent necessity, according to the observations of some astronomers, of internal density, we are at a greater loss than ever to come to a determination, which might either satisfy ourselves, or be offered for the satisfaction of others; an uncertainty which is by no means lessened, although certainly left open to discussion, when we observe such different opinions upon this very subject, as those we are about to subjoin.

The accomplished author of the Connexion of the Sciences, says—

"But a density so extreme, is not borne out by astronomical observation. It might seem to follow, therefore, that our planet must have a widely cavernous structure, and that we tread on a crust or shell whose thickness bears a very small proportion to the diameter of the sphere. Possibly, too, this great condensation at the central regions may be counterbalanced by the increased elasticity due to a very elevated temperature."*

"It has sometimes," says Professor Whewell, "been maintained by fanciful theorists, that the earth is merely a shell, and that the central parts are hollow. All the reasons we can collect appear to be in favour of its being a solid mass, considerably denser than any solid rock."†

"Taking water at a temperature of 60° as the unit of comparison," says Professor Phillips, "we find the specific gravity of the superficial parts of the globe, as judged of by weighing the most

* Connexion of the Sciences, p. 90.

† Bridgewater Treatise, p. 50. The remaining part is recommended to the perusal of our readers.

prevalent rocks, to be 2.5. By direct experiment, and comparison of the local attraction of mountains and insulated masses of matter with the general attraction of the globe, the mean density of our planet has been inferred to be about five times that of water. This result is found sufficiently in accordance with astronomical considerations, to allow us to adopt it for geological reasoning.

"The interior parts of the globe must therefore be denser than the exterior rocks.

"From the influence of the earth on the moon's motions, it is inferred, that the internal mass of our planet augments in density towards the centre; the surfaces of equal density being symmetrical with the external spheroidal surface. The materials of the earth have therefore collected round the centre in obedience to the laws of gravitation and rotatory movement, and the internal substances, as having fallen to the lower place when freedom of motion was allowed, would probably be heavier under the same circumstances than the superficial substances, and so forth. . . . . . Now though we cannot presume that the laws of compression would hold in these bodies to such an extent, enough is known to justify a confident belief, that the mean density of our planet would be very much greater than it is, were not the tendency to enormous condensation in the central masses, counteracted by some powerful agent of expansion, such as heat, or neutralized by some peculiar or unknown constitution of the substances themselves."*

Dr. M'Culloch, when treating incidentally on this, says—

"Notwithstanding its inferiority in position, we must not grant, as asserted, that granite constitutes the mass of the globe, or is the lowest rock in existence. Of the interior of the globe we know nothing; but its weight is sufficient to prove, that it is not formed of granite. . . . . . Some unstratified matter, solid or fluid, does doubtless lie beneath the stratified surface of the earth; but while conjectures are fruitless, it might, if solid, be basalt as well as granite."†

We find others expressing bolder and more startling views of this perplexing subject, derived, no doubt, from the gradual

* Treatise on Geology, pp. 9—11.

† Vol. ii. p. 87.

increase of heat which is experienced when perforations are made into the solid parts of the earth's crust.

"That the whole interior portion of the earth, or at least a great part of it, is an ocean of melted rock, agitated by violent winds, though I dare not affirm it, is still rendered highly probable by the phenomena of volcanoes. The facts connected with their eruption have been ascertained and placed beyond a doubt. How then are they to be accounted for? The theory prevalent some years since, that they are caused by the combustion of immense coal beds, is puerile and now entirely abandoned. All the coal in the world could not afford fuel enough for one of these tremendous eruptions of Vesuvius."*

How infinitely would the first of these conceptions—that of Mrs. Somerville—if eventually found to be correct, tend to exalt our ideas of the wisdom, and the power of God, who disposed and prepared the rocky shell in such a way, that while, by his command, it was transformed from a level sphere, "without form and void," into a spheroid, adorned with continents and ocean beds, hills and dales, yet was so cemented and welded together, in the very act of its transformation, that neither the elastic fluids were permitted to escape from within, nor the water to penetrate the superficial crust!

But, as we have before remarked, while this recondite point in cosmogony is shut up from experimental investigation, and thereby exposed, less or more, to conjecture, its importance seems to be inversely as the difficulty of its determination. The earth's formation can be satisfactorily accounted for even should this be assumed, merely in conformity with the requirements of interplanetary laws.

Nevertheless, we take occasion to observe, that this abstruse question has been so far benefitted by the Dynamical Theory, that it has removed the seeming necessity which there appeared to be, for not only taking fierce *internal heat* into the resolution of the problem, but for subordinating all the other conditions to this datum, supposed to be so well established.

* Professor Silliman. Am. Journal of Science.

Henceforward, we trust, that the heat, discoverable in mines and other perforations, will be attributed to that which was caused by the friction of the moving mineral masses, during the earth's protorotation, and whose foci resided in mountain nucleii; as this of itself is quite sufficient to have produced the phenomena in question; while the Dynamical Theory would have been incomplete without the existing demonstrations of fierce heat in these localities.

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXV.

The immediate consequences of the two established positions: the non-rotation of the earth until all the strata, up to the coal measures, had been formed; and its subsequent protorotation, considered with reference, firstly, to the rush of water which took place from the poles towards the equator; and, secondly, to the disintegration which accompanied the upbursting of the amorphous rocks, during these violent movements of the primitive water. This conflux of water attempted to be explained analogically by currents of wind; and applied to the peculiar case under consideration. The attention then directed to another simultaneous series of events. The upbursting of the amorphous masses, and the disintegration which must have ensued, together with the disseminating effects of the violent aqueous currents towards the equator. Geological evidences. Some brief concluding observations.

Having thus established the fundamental positions, That the earth existed in a state of non-rotation during a period sufficiently long to admit of the deposition of all the stratified formations up to the completion of the coal measures; and, that its protorotation took place on the first day of the Mosaic week; we have, in continuation, to consider two of the more important of the manifold consequences which resulted from the commencement of the earth's diurnal motion at the period to which we have alluded. These are so intimately allied to each other in the effects which they, in turn, produced on the geological developments of the earth, that it would be most desirable could they, by any means, be described simultaneously, but this not being possible, we must submit to their being

considered in immediate sequence. We allude, firstly, to the rush of water which took place from the polar seas towards the equatorial regions to complete the figure of equilibrium; and, secondly, to the comminuting and disintegrating influence conjointly of this sudden movement of the water, and of the upheaving of the unstratified masses, when they burst through the strata in obedience to the centrifugal impetus occasioned by the first rotation of the earth around its axis.

A rush of water, similar to that which is here alluded to, never having been thought of by philosophers, no provision has been made for it; and, therefore, in place of being able to produce direct testimony to show what would be the consequences of a world of water thus thrown into sudden and violent movement, and sweeping over rocky masses in the act of disintegration and comminution, and also in agitation, we are necessitated to reason by analogy, and to adopt the case which nearest approaches to it. For this purpose, we find the clear and convincing exposition which has been given of the trade winds, to be very analogous, the appropriate points of which compose the *thirty-fifth* Theorem, which states, "*That a satisfactory explanation of the trade winds has been given upon certain well-known and established principles, amongst which the following are relevant to the present subject :* 1*st. That all portions of the earth's surface have a velocity of rotation in direct proportion to the radii of the circle of latitude to which they correspond; 2nd. That the air, when relatively and apparently at rest, is only so because it participates in the motion of rotation proper to that part of the earth; 3rd. That, consequently, when currents of air set towards the equator from the north or south, they must lag, hang back, or drag upon the surface, in a direction opposite to that of the earth's rotation, or from east to west; and, lastly. That the polar currents, from a deficiency of rotatory velocity, tend by their friction, near the equator, to diminish the velocity.*"

The following evidences corroborate the truth of this interesting Theorem, although they are necessarily restricted to the points which alone affect this theory :—

"Another great geographical phenomenon, which owes its existence to the earth's rotation, is the trade winds. These arise from,

1st, the unequal exposure of the earth's surface to the sun's rays, by which it is unequally heated in different latitudes; and, 2ndly, from that general law in the constitution of all fluids, in virtue of which they occupy a larger bulk, and become specifically lighter when hot than when cold. These causes, combined with the earth's rotation from west to east, afford an easy and satisfactory explanation of the magnificent phenomena in question. . . . . .

"Since the earth revolves about an axis passing through the poles, the equatorial portion of its surface has the greatest velocity of rotation, and all other parts less in the proportion of the radii of the circles of latitude to which they correspond. But as the air, when relatively and apparently at rest on any part of the earth's surface, is only so because in reality it participates in the motion of rotation proper to that part, it follows, that when a mass of air near the poles is tansferred to the region near the equator, by any impulse urging it directly towards that circle, in every point of its progress towards its new situation, it must be found deficient in rotatory velocity, and therefore unable to keep up with the speed of the new surface over which it is brought. Hence, the currents of air which set in towards the equator from the north and south must, as they glide along the surface at the same time, lag, or hang back, and *drag upon it* in the direction *opposite* to the earth's rotation, *i. e.* from east to west. Thus these currents, which but for the rotation would be simply *northerly* and *southerly* winds, acquire from this cause a *relative* direction towards the *west*, and assume the character of permanent north-easterly and south-easterly winds. . . . . . It follows, then, that as the winds on both sides approach the equator, their easterly tendency must diminish. The length of the diurnal circles increase very slowly in the immediate vicinity of the equator, and for several degrees on either side of it hardly change at all. Thus the friction of the surface has more time to act in accelerating the velocity of the air, bringing it towards a state of *relative* rest, and diminishing thereby the relative set of the currents from east to west, which on the other hand, is feebly, and at length not at all reinforced by the cause which originally produced it. And arrived at the equator, the trade winds must be expected to lose their easterly direction altogether. . . . . . All these consequences are agreeable to observed fact, and the system of aërial currents above described constitute in reality what is understood by the regular *trade winds*.*

* Astronomy, by Sir John Herschel, Cab. Cyc. pp. 128—132.

This will be found to be fully corroborated by the following observations of Mrs. Somerville:—

"In consequence of the combination of all these circumstances, given in the context, two great currents, in the ocean, perpetually set from each pole towards the equator. But, as they come from latitudes where the rotatory motion of the surface of the earth is very much less than it is between the tropics, on account of their inertia they do not immediately acquire the velocity with which the solid part of the earth's surface is revolving at the equatorial regions; from whence it follows, that within 25 or 30 degrees on each side of the line, the ocean appears to have a general motion from east to west, which is much increased by the action of the trade winds."

And again—

"Although the attraction of the sun and moon has no sensible effect on the trade winds, yet, the heat of the sun occasions those aērial currents, by rarefying the air at the equator, which causes the cooler and more dense part of the atmosphere to rush along the surface of the earth to the equator, while that which is heated is carried along the higher strata to the poles, forming two counter currents in the direction of the meridian. But the rotatory velocity of the air, corresponding to its geographical position, decreases towards the poles. In approaching the equator, it must, therefore, revolve more slowly than the corresponding parts of the earth, and the bodies on the surface of the earth must strike against it with the excess of their velocity, and, by its reaction they will meet with a resistance contrary to their motion of rotation. So that the winds coming from the polar regions, will appear . . . . . to blow from the north-*east* on the one side of the equator, and from the south-*east* on the other, which is the direction of the trade winds."*

With manifest allusion to the rush of water which occurred from the polar towards the equatorial regions of the earth, on its first rotation taking place, there are two sublime passages in Scripture: one in the Book of Job, another in the Psalms, which, however distinct they may be from philosophical evidence, and although one has already been quoted, we cannot refrain from introducing here; the more so, as, in the absence

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* Connexion of the Sciences, pp. 115, 137.

of *direct* proof, or that which is appreciable by the senses, the testimony of Him who only could know what then took place can alone be appealed to. "Where wast thou," demands the Almighty of his afflicted servant, "when I laid the foundations of the earth? declare, if thou hast understanding. . . . . Who laid the corner-stone thereof, when the morning-stars sang together, and all the sons of God shouted for joy? *Or who shut up the sea with doors, when it brake forth as if it had issued out of the womb? When I made the clouds the garment thereof, and thick darkness a swaddling band for it, and brake up for it my decreed place, and set bars and doors, and said, Hitherto shalt thou come, but no further; and here shalt thy proud waves be stayed.*"* And again, "Who laid the foundations of the earth, that it should not be removed for ever. Thou coveredst it with the deep as with a garment: the waters stood above the mountains. At thy rebuke they fled; at the voice of thy thunder they hasted away. The mountains ascend, the valleys descend into the place which thou hast founded for them. Thou hast set a bound that the waters pass not over; that they turn not again to cover the earth."†

Returning to, and applying the philosophical quotations, relative to the trade winds, to the case under consideration, namely, a primitive circumfluent ocean of uniform depth, reposing in its *then* static condition of spherical equilibrium upon the non-rotating world; and conceiving the whole to have been put suddenly into motion from West to East, with an angular velocity of 15° per hour, it is evident, that in order to regain the state of rest from which the water had been aroused, and to which it would seek to return, it would hasten to assume the level of form which corresponds to equilibrium under rotation; that is, such a change would be produced in the entire mass, as would have the effect of raising the water of the equatorial regions thirteen miles above the level of those at the poles; or what is the same, a line passed through the equatorial ocean, would measure twenty-six miles more from surface to surface, than a diameter taken from pole to pole.

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* Job xxxviii. 1—11. † Psalm civ. 5—9.

To acquire this form of equilibrium there would, of course, be a transfer of water from the polar to the equatorial regions; and, as this transformation was effected in forty-eight hours, the velocity of the current would be inconceivably violent; while its retardation, or lagging behind, from the difference of velocities in the aqueous zones, corresponding to the radii of the circles of latitude, as the water hastened towards the equator, would be correspondingly great. Consequently, as in the case of the trade winds, instead of forming a direct southerly current from the North Pole, and a northerly one from the South Pole, that overwhelming rush of water would assume a *westerly* direction as it approached the equatorial regions from both of these extremities; and thus tend to mitigate the centrifugal impetus of the inter-tropical ocean; which, although of the same specific gravity as the more distant seas, would, from the form and rotation of the earth, be unavoidably subjected to a much more intense degree of centrifugal impetus; and might have been, but for this provision wisely ordained to counteract it, entirely whirled off the surface of the globe!

From the very lucid explanations, we have just perused, of the origin of the trade winds, it will have been observed, that one of the procuring causes is the inertia of the atmosphere, or, in other words, the earth's attraction causing it to adhere to and perform rotatory motion, corresponding to its *geographical* position, or the zones of latitudes over which the wind exists; and, as in the immediate context to the *rationale* which Sir John Herschel has given of this interesting natural phenomenon, we have the following rule—that "the weight of a body (considered as undiminished by centrifugal force), is the effect of the earth's attraction on it"—it follows, as a matter of course, that this action, on the part of the earth, *will be as much more powerful on water as it is on air, in proportion as water is heavier than air;* and, consequently, this *lagging* or *westerly* direction in the rush of *water* from the poles towards the equator would be much more certain and excessive than is now experienced to be the case with the trade *winds*.

Counteraction, however, was only one of the many important services which this mighty rush of water was designed to per-

form. But as it is essential to unfold other effects which were simultaneously taking place, in order that the co-resultant consequences may be thoroughly and more easily comprehended, we shall leave this particular branch of our subject, for the present, in the state in which we have placed it, with the intention of resuming it shortly hereafter; while, in the meantime, we cannot avoid being vividly impressed with admiration and astonishment at the power, and the wisdom of that Omnipotent Being, who could thus "mete out the oceans in the hollow of his hand, and wield them at his sovereign pleasure!" Who could "set bars and doors unto them," and say, "hitherto shalt thou come, but no further, and here shall thy proud waves be stayed!"

We shall, therefore, now direct the attention to another series of events which were going forward contemporaneously with those which we have lately been describing. We allude to the disintegrating and comminuting effects of the protruded rocks, as they burst through their overlying stratified envelopes; and spread about with explosive violence, an immense body of *debris* of all descriptions, from the massive boulder to the impalpable soil; swept away instantaneously by the water, and destined to form newer and unconformable strata in the rugged hollows occasioned by the elevation of those very mountains which caused the disintegration.

In a former part of this section we estimated the increase of surface which the earth, on being transformed from a sphere to a spheroid of rotation, had undergone, at upwards of *eight hundred and sixty-one thousand square miles*, by a computation of plane surfaces. It will also be remembered that the part at present covered by the ocean, is in proportion to that which is dry, as 3 is to 1; therefore, were we to go strictly to work, we should justly consider, that only one-fourth of the above increase of surface pertains to our present continents; or to that portion, which being above the level of the ocean, may be subjected to geological investigation. But the great bulk of the increase which the globe underwent having been within a zone of from thirty to thirty-five degrees on each side of the equator, where the centrifugal impetus was most felt, and where the land is in greater proportion, impartiality demands

that a more liberal concession should be made; we shall, therefore, consider, that the portion above the level of the ocean underwent an aggregate increase equal to one-half of the above quantity, or about *four hundred and thirty thousand square miles.*

Now, the entire surface of the globe, computed from its two given diameters, is 196,878,115 square miles; consequently, its portion above the level of the sea, even taken at one-fourth part (which we did not exact, though willing to allow), is, in round numbers, *forty-nine millions two hundred and twenty thousand square miles,** which stands to the supposed portion of the enlarged surface last mentioned, in the proportion of about 1 to 115. It is very difficult, if not altogether impossible, to determine the exact proportion which the aggregate surface of *protruded rocks of all descriptions* bears to that which is still covered by the original stratifications; and the more so, as much space was covered over, and consequently hidden from examination, by the very *detritus* whose existence we are at present endeavouring to substantiate; but certainly, an impartial review of the geographical outlines of the earth's surface will convince us, that the proportion of a *one hundred and fifteenth part* for unstratified and other protruded rocks, sinks into insignificance when compared with what is actually known to be their true proportion.† In prosecuting this argument, it is clearly to be understood, that according to the principles of the present theory, not only the unstratified masses of every description, but likewise all strata which are tilted out of horizontality, are to be considered *protruded rocks,* from their now occupying a part of the surface formerly covered by the concentric layers of the ancient world; and consequently by their having added to the general disintegration.

It may easily be imagined with what satisfaction we find ourselves enabled, whilst in such a difficulty as this, to adduce

* We have much pleasure in stating, that these calculations have been examined and confirmed by Lieut. Alexander R. Clarke, of the Royal Engineers, and can therefore be thoroughly relied on, our young friend's acquirements in such questions being well known.—Author.

† Professor Phillips estimates the proportional surface covered by strata horizontal, or nearly so, at three-fourths the whole area. Page 59.

the evidence of so shrewd and intelligent a writer as the commentator of Hutton, on a point of so hypothetical a nature, *as the supposed proportion which the primary rocks bear to the others;* and we consider it a still more fortunate circumstance, that where this is elicited in his writings, it should have been with a view to vindicate his friend from a charge brought against him by Mr. Kirwan, of having *underrated* the proportion which granite bears to other rocks, for, on that account, it is to be presumed, that *he would not admit one square mile of surface into his computations, which could, consistently with truth and justice, be excluded.* Therefore, his evidence must be considered quite impartial when brought forward to substantiate an argument, during which a desire to carry our point might probably have led us into the opposite error, even should there be any one foolhardy enough to entertain a suspicion of the correctness of Prof. Playfair's statements, trained as he was to the investigation of truth in its most abstract form. But to proceed—

"A remark," says he, "which Dr. Hutton has made on the quantity of granite that appears at the surface, compared with that of other mineral bodies, has been warmly contested. Having affirmed, that the greater part of rocks bear marks of being formed from the waste, and decomposition of other rocks, he alleges that granite (a stone which does not contain such marks) does not, for as much as appears from actual observation, make up a tenth, nor perhaps even a hundredth part of the mineral kingdom. Mr. Kirwan contends that this is a very erroneous estimate, and that the quantity of granite visible on the surface, far exceeds what is here supposed. The question is certainly of no material importance to the establishment of Dr. Hutton's theory; it is evident, too, that an estimation, which varies so much as from a tenth to a hundredth part, cannot have been meant as anything precise; yet, it may not be quite superfluous to show, that the truth probably lies nearer to the least than to the greatest of the limits just mentioned."

After observing that the extent of surface occupied by granite in the immediate vicinity of Mont Blanc, does not exceed one-tenth part of the rocky surface; that none is found in the route across by Mount Cenis; that in other parts of the Alps

it is about one-sixth; throughout the Pyrenees it may be estimated at one-fifth part of the whole mountainous part; he concludes on the whole, that the proportion of granite to schistus, is that of one to four, and then goes on to give the evidence which more immediately affects our present argument in the following words—

"It remains," says he, "to form a rough estimate from maps, and from the accounts of travellers, as to what proportion of the earth's surface consists of primary, and what of secondary rocks. After supplying the want of accurate measurement, by what appeared to me the most probable suppositions, I have found, that about *one-eighteenth part* of the surface of the old continent may be conceived to be occupied by primitive mountains; of which, if we take one-fifth we have a *ninetieth* for the part of the surface occupied by *granite rocks*, which differs not greatly from the last of the two limits assigned by Dr. Hutton."*

It must be observed, that in Dr. Hutton's theory, the primary strata comprehended, "besides gneiss, the micaceous chlorites, hornblende, and siliceous schistus, together with slate, and some other kinds of argillite," as also "talcose schistus, and lapis ollaris, or potstone."† These, together with the granitic rocks, are included in those which he considered occupying *one-eighteenth* part of the surface of the old continent. But, as our present object is to determine, if possible, the extent of *the protruded rocks of every description,* the preceding data are only available in having fixed a determinate proportion of surface occupied by certain known rocks of the primitive class, and as to them are to be added, not only the trap, porphyritic, and greenstone veins and dykes; the old red sandstone and the mountain limestones; but even the coal measures themselves, wherever out of horizontality, and appearing at the surface; the above fraction of one-eighteenth may, on their account, and on that of the whole protruded rocks of every denomination, be so augmented in value, as that their aggregate extent shall be estimated at about *one-thirteenth* of the exposed surface; which is, certainly, a moderate pro-

* Professor Playfair's Works, vol. i. pp. 341—344. † Ibid, pp. 29, 170.

portion, as may be perceived by surveying any geological map of extensive area.

Assuming, then, the dry surface of the whole globe, as before stated, to be 49,220,000 square miles, one-*thirteenth* of it is somewhat more than *three millions seven hundred and eighty-six thousand square miles* of surface measurement, over which it is estimated that the protruded rocks extended themselves when they burst through the superincumbent strata; and, therefore, an equal number of square miles of stratified rocks, which have disappeared or been tilted up from the position of horizontal continuity they once occupied, require to be accounted for, or, in other words, it must be shown how this vast space was filled up by intruded rock, in order that the Dynamical Theory may not be considered imperfect.

It must appear evident to every reflecting mind, that owing to the manner in which the stratified masses were removed, and the violence with which the others were thrust into their places, through such great depths of aggregated layers of strata, immense disintegrating and comminuting effects must inevitably have ensued. We mean, even beyond those which produced the breccias and conglomerates lately treated of. Indeed, in many instances the strata must have been ground down to an impalpable powder; while in others, both they and the protruding rock would be broken into fragments of every conceivable dimension, from the smallest gravel to the most massive boulder; and, altogether, there would be such an explosion—a tumultuous explosion of rocky material, as the world never witnessed before: nor, as long as time continues, will it ever witness again!

It is only after having been made aware of the prevailing extent of this catastrophe that we are enabled to perceive, in its full extent, the consummate wisdom, and the harmony of design on the part of the Omnipotent, *in providing a rush of water all over the globe at this precise and important juncture.* Had the operations we have thus attempted to describe, been conducted without the presence of water, the rocky and stony *debris* would, by their natural gravity, have accumulated around the bases of the protruded hills in rugged, unconnected, and unproductive tumuli, as is the case in the vicinity of

modern volcanoes; while, on the other hand, had there been merely water, without its having been in violent agitation and motion, the subsidence of the mineral debris would have been much too immediate, and the effects it was destined to produce would have been left almost wholly unaccomplished. But, by the union of these two conditions, the mineral and earthy materials, deprived by the water of a great proportion of their specific gravity, were borne along in mechanical suspension with inconceivable rapidity, and spread over the rocky hollows formed by the elevation of the masses which occasioned the spreading abroad of that very mineral material destined to round off their scarped and rugged half-formed scenery, such as we have supposed it to be up to this date, and to render the whole surface a more choice habitation for man and the animals which were soon thereafter to be willed into existence. Whilst we beg it may be observed, as one of the most opportune and wise arrangements in this wonderful operation, that "the lagging of the waters" as they reached the equatorial regions, not only moderated the rush of those within that zone, but the meeting of the two currents brought the united flood sooner to rest, and enabled the converging torrents more instantaneously and more effectually to discharge themselves of their loads of earthy matter with which they had been dispatched thither from their respective polar extremities; when the protorotation allowed them no longer to slumber around these new-formed pivots of the earth. So wonderful are the works, and so harmonious are the designs of the Great and Omniscient Creator! "How manifold are thy works, O Lord! in wisdom hast thou made them all; the earth is full of thy riches."*

So complete a corroboration of the view which we adopt of the origin of this unconformable series of rocks, is given by M. de la Beche, when summing up his opinion of the new red sandstone group, that we cannot refrain from giving an epitome of it, although in detached sentences:—

"If, says he, "we abstract our attention from its sub-divisions

* Psalm civ. 24.

and regard the group as a mass, it would seem to constitute the base of a great system of rocks, which, when not deranged by local influences, has filled numerous hollows and inequalities of land. . . . United with the great capping of the oolitic group, which, for the most part, rests so conformably upon it, they, together, would seem to fill up great depressions in Europe. . . . . . During their deposit, great and remarkable changes were effected in animal and perhaps in vegetable life. Very extensive tracts of red sandstone exist in Mexico and South America, but whether contemporaneous with those of Europe, the state of science does not permit us satisfactorily to determine. The porphyries and slates of New Spain are surmounted by red conglomerates and sandstones, forming the plains of Celaya and Salamanca. . . . . . In Venezuela the vast plains are, in a great measure, covered by red sandstones and conglomerates deposited in a concave manner between the coast mountains of Carracas and those of Parima. . . . . . An immense extent of red sandstone is described as covering nearly without interruption the southern plains of New Granada, the basin of Rio de la Magdelena, and Rio Cauca, between Carthago and Cali. . . . . According to Humboldt, the Cordilleras of Quito presented him with the greatest extent of red sandstone which he had observed, covering the whole plateau of Tarqui and Cuenca for twenty-five leagues; and the same also occurred, he adds, in Upper Peru, while he remarks on the resemblance of these rocks of Mexico, New Grenada, Peru, and Quito, to the red sandstone, or *Todtliegendes* of Germany. . . . . .

"A series of red sandstones intermixed with conglomerates also occurs extensively in Jamaica. . . . . . These rocks appear to be the equivalent of those named red sands in the neighbouring continent of America. . . . . . The mere mineralogical resemblance of this deposit in America and Jamaica with the sandstones and conglomerates of the red sandstone group of Europe is in itself of no great value, and, therefore, we can only at present conclude, that considerable forces have been exerted in both parts of the world (whether contemporaneous or not remains to be determined), which have dispersed fragments of pre-existing rocks, scattering them, most probably by the medium of water violently agitated, in various directions, the transporting powers being unequal, so that sandstones and marls alternate with conglomerates; so that, if different deposits have not been confounded under one head, those sandstones and con-

glomerates would appear, not the result of a limited disturbance, but of one common to a considerable surface."*

Professor Phillips confirms this when he says—

"The next succeeding deposit, which receives the name of red sandstone, or saliferous, or poecilitic formation. . . . . . almost universally fills a low or level country, out of which arise insulated groups and short ranges of mountains of old strata or of pyrogenous rocks. . . . . . The system consists of many alternations of arenaceous and argillaceous members, with some less continuous interpositions of limestone usually impregnated with magnesia. . . . . . Thus the whole is capable of being represented in one formula, which is well calculated to show both the agreement and differences usually observed in comparing distant parts of a stratified formation."†. . . . .

"Salt is associated with the upper parts of this system in England, France, and Germany, where the muschelkalk is quite as saliferous as the variegated marls to which, apparently, salt is confined in England. Upon the whole, therefore, the red sandstone system is a vast mass of sandy and argillaceous sediments of a peculiar aspect, accompanied more than any others yet known by salt and gypsum, generally deficient in organic remains, and only locally enclosing strata of limestone, which commonly are characterized by abundance of magnesia."‡

The denuding and sweeping action of a vast body of water seems, by the following passage from Mr. Miller's work, to have likewise been recognised by him in the geological developments of those parts which he examined:—

"The curtain again rises," says he, "a last day had at length come to the period of the middle formation; and in an ocean roughened by waves and agitated by currents, like the ocean which flowed over the conglomerate base of the system, we find new races of existences. . . . . . The depositions of this upper ocean are of a mixed character; the beds are less uniform and continuous than at a greater

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* Manual of Geology, by M. de la Beche, 2nd edition, pp. 409—412.

† We would recommend our readers who may have the opportunity to refer to this formula.

‡ Treatise, pp. 119, 120, 123.

depth. In some places they consist exclusively of sandstone, in others of conglomerate; and yet the sandstone and conglomerate seem, from their frequent occurrence on the same platform, to have been formed simultaneously. The transporting and depositing agents must have become more partial in their action than during the earlier period. They had their foci of strength and their circumferences of comparative weakness; and while the heavier pebbles which compose the conglomerate were in the course of being deposited in the foci, the lighter sand which composes the sandstone was settling in those outer skirts by which the foci were surrounded. At this stage, too, there are unequivocal marks in the northern localities, of extensive denudation. The older strata are cut away in some places to a considerable depth, and newer strata of the same formation deposited unconformably over them. There must have been partial upheavings and depressions, corresponding with the partial character of the depositions; and, as a necessary consequence, frequent shiftings of currents. The ocean, too, seems to have lessened its general depth, and the bottom to have lain more exposed to the influence of the waves."*

We have already, in a former part of this work, alluded to one very important service performed by the *debris* here spoken of, namely, *protection to the vegetable beds which now constitute our principal coal fields.* It not only saved these from being washed away by the denuding influence of the water thus thrown into violent movement, but by covering them, it likewise preserved them effectually from the atmosphere which was shortly afterwards to be formed, and by their gaseous ingredients being thus confined, they were rendered fit for our present purposes, as great carbonaceous deposits. It must also be added, that another very wise and beneficent design was carried into execution, by the arrangement which impelled the water from the poles towards the equatorial regions. In the latter zone, the mountains having risen to a greater height by the increased centrifugal impetus, a proportional quantity of loose, stony, and earthy material would necessarily be requisite to fill up their deeper hollows, and more rocky and rugged acclivities; but as, at that period, the aggregate depth

* Old Red Sandstone, pp. 310, 311.

of the strata was uniform all over the spherical earth, it is evident, that the mere elevation of the protruded rocks, although to greater heights, would not have been sufficient to have supplied the *debris* required for that purpose. Hence, in the sudden rush of water, laden with earthy materials from either pole, towards the equatorial regions, and it being there brought to rest and made to unladen itself of its burden, we behold a wise and harmonious combination; wherein the several circumstances are made to concur towards the completion of the design then in contemplation. Nothing could have been better adapted for supplying the wants in these regions, and for completing the habitable portions of its surface, than this seasonable supply of earthy matter, borne along by the rushing water, and deposited where so much needed; while, at the same time, the more extreme latitudes were relieved, by disintegration and denudation, from an immense mass of loose material, which would have been positively prejudicial where it was originally formed, had it been *there* redeposited.

Other attendant circumstances, displaying the infinite wisdom of the whole design, ought, by no means, to be overlooked. We allude, in the first place, to the modified state of the oceanic water itself, which, during a protracted course of preparation, had been deprived of the greater part of those previously combined gases, which, had they been permitted to exist in the water at the period we now refer to, would have redissolved the earthy material which was designed to be merely mechanically disseminated throughout it; and, by demanding a fresh chemical process, have been inimical to the intention then in view, of mechanical suspension only, and almost instantaneous deposition. Next, we allude to the admirable adaptation of the agent employed for effecting, in the most appropriate manner, the deposition of the earthy material, which was thus sent to make a smooth and habitable soil, from a heterogeneous mass of boulders, fragments, gravel, sand, and finely comminuted earthy soil; as it must be self obvious, that according to the laws affecting them, they would be deposited from the liquid carrier in proportion to the sizes of the fragments, particles, &c., and thus the asperities would be rounded

off at the same time that the land itself was formed. Similar reasons will also explain how the more massive boulders, in many instances, would be deposited near to the site of their parent rocks, while the finer particles would be conveyed, even to within the tropics, to fill up and form the extended table lands of these regions, and constitute those almost interminable depths of light calcareous soil, which so frequently characterise those elevated plains, across whose broad and fertile surface it has so often been our lot to travel; and to view with wonder and amazement the great depth of the accumulated soil, sand, and gravel, exposed by deep ravines, and laid bare by the river courses when these were reduced to rivulets during the dry season.

It will have been observed, that in these investigations, we have taken no notice whatever of the saliferous deposits which, so generally, are associated with these widely-spread arenaceous formations; it is our intention to treat very fully of these in a subsequent part of this work, after having explained our views respecting the formation of the atmosphere, according to the Dynamical principles of this theory. Neither have we alluded in any manner to the remaining three-fourths of the earth's surface, or the part which constitutes the bed of the ocean. Over all that area, no doubt, somewhat similar events would be taking place, to those which were occurring on the terrestrial portion of the globe; but as the *debris* occasioned in the oceanic part would be precisely proportioned to the surface over which it was spread, the quantities being equal, in both terms of the equation, they can be eliminated, or disregarded entirely, without affecting the correctness of the general argument.

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXVI.

The previous subject continued. Formation of Earths and Soils. The attendant circumstances peculiarly favourable for this needful process. The unconformable rocky masses which overlie the coal measures. Geological evidence of their existence. Enquiry into their origin, as made known to us by the Dynamical Theory. Geological character of the newer Secondary Suites. The New Red Sandstone, the Oolitic, and the Cretaceous groups. Their saliferous associates reserved for a future Section. The Supra-cretaceous deposits, as explained by this Theory, and the clear line of demarcation which it draws between them and the still more recent surface accumulations, the residium of the Deluge.

To make manifest that everything was arranged by a Wisdom which is infinite, and that all the attendant circumstances were made to conspire towards the completion of the great plan of creation, then progressively and rapidly being unfolded, we shall, at this opportune juncture, direct the attention to the nature and formation of *earths and soils.* In doing this, we shall merely recapitulate, in succession, those Theorems which have reference to these substances. The subjects they treat of being quite of an elementary character, we do not consider it requisite to detain the general argument by bringing forward their evidences; reference may therefore be made to their respective authorities, should any doubts be entertained, or further information required on the subject. In passing, however, we may take occasion to mention, what may perhaps not be so generally known, namely—that some celebrated French chemists have discovered, and satisfactorily

proved, that when the contained oxygen has been doubled in water, its oxydizing power is greatly augmented, the oxydation, and consequently the formation of the bases of earths, when it is in this state, going on with a rapidity almost inconceivable. Having made this advertency, we hasten to unfold the general outlines of this additional and conspicuous instance of that provident forethought and consummate wisdom which made all things work together for the accomplishment of His great designs. In the present instance, the chief object having been the formation of an appropriate bed of earthy soil, to receive and sustain that rich and magnificent vegetable covering which was so soon to be thrown over and to adorn the new formed land, composed of an attractive variety of foliage, of flowers, and of fruits, brought forth, by the word of His power, in maturity and perfection. The *ninety-eighth* Theorem states, "*That earthy matter consists generally of some metallic substance in chemical combination with oxygen, forming an oxide. That the combination of earthy metals with oxygen usually takes place when favoured by a sufficient elevation of temperature. That this constitutes the important change which many metals undergo when heated under exposure to the air. And that, to facilitate this combination, it is necessary to raise their temperature considerably, to some metals it being even requisite to apply very intense heats.*

When we reflect on the stupendous chemical process then going on, the introduction of heated continents and mountains abounding with metals and metalloids, into the midst of a universal ocean, plentifully saturated with oxygen, and on the increased powers of oxydation which water possesses when its associated oxygen is augmented, we are forced to exclaim, "This indeed was a laboratory worthy of the Creator, when producing the materials for the soils of a world!" Any observations by us on a subject such as this would be wholly superfluous. To those who can appreciate its magnificence they will be unnecessary; to those who cannot they would be of no avail! We shall, therefore, go on to exhibit the manner in which these earthy oxides are generally removed from where they are formed; and, last of all, enumerate the remaining substances which contribute to the formation of

perfect soil; and throughout the whole, there will be observed the same wise adaptation of means to the desired end.

The manner in which sands and soils are at present formed is under atmospheric influences. Although the atmosphere, and consequently, none of its meteorological changes, were in existence at the period to which we allude, yet it is presumed, that in the primitive ocean, abounding with carbonic acid and free oxygen, thrown into violent motion and agitation, there existed elements in every respect equal in effect, and superior in power, to those which are now in daily operation repairing the continual waste of soil absorbed in vegetation, and swept into the ocean by rains, rivers, &c.; consequently we may look upon the original method of formation, as that which produced the stock, constituted under strong and powerful influences, while the latter is destined merely to keep it up by atmospheric agency.

With respect to the material itself, the *hundred and fourth* Theorem states, "*That, in order to form a just idea of soil—which consists of small stones and sand, impalpable earthy matter, decaying animal and vegetable substances, and small quantities of salts—it is necessary to conceive different rocks to be decomposed and ground to fineness, some of their soluble parts dissolved in water, and that water adhering to the mass, and the whole mixed with the remains of vegetables and animals in different stages of decay, together with small portions of salts; the earthy matter, however, constituting their chief proportion. And that when the mineral ingredients of soils are traced to their ultimate elements, they are found to consist chiefly of silica, alumina, magnesia, and the oxides of iron and of manganese.*"

Bearing this information, and that which we acquired in the previous chapters in mind, and applying it to the operations going forward on the *first* and *second* days of the Mosaic week, it will be acknowledged, that every requisite element was present for the production, in the shortest possible period, of a quantity of siliceous and calcareous materials, which, when joined to the *debris* spread abroad by the explosion of the protruded rocks, when they burst through the superincumbent strata, would be sufficient to form, by subsequent deposition,

those unconformable suites which overlie the *coal measures*, the remains of the submarine vegetation of the primitive world, and also other portions of the original surface.

Therefore, in pursuance of the method hitherto observed, it is now requisite to enquire whether geologists recognise any formations, whatever be their denomination, which correspond in character to the material here supposed to have been spread abroad. If we set aside, for the present, the limitations imposed upon us by the nomenclatures of the various geological systems, and take a comprehensive view of the mineralogical and geological characteristics of these formations themselves, we shall discover, with peculiar satisfaction, in the proofs which geology affords, a striking corroboration of the views we have adopted, so much so, indeed, that the substance of the following evidence may be summed up in one brief sentence, namely, every formation superior to the carboniferous group, and those of the same era, affords evident symptoms of having been deposited from a heterogeneous mass of mineral *debris*, occasioned by some great and general catastrophe; while the coal series themselves, with the mountain limestone, and old red sandstone, which underlie them, exhibit as evident symptoms of having together undergone some violent movement about the same period.

To prove this, we shall undertake a new series of enquiries, commencing with what is contained in the *thirty-first* Theorem, which states, "*That in the coal measures there is considerable persistency of character; those termed 'independent' being usually found in strata conformably to and overlying the mountain limestone and the old red sandstone; the whole three formations appearing to have been moved simultaneously, by the influence of great force, from where they were originally formed. That the magnesian limestone and new red sandstone, which usually overlie the coal measures, are, on the other hand, unconformable to them and more horizontal in their position. That the lower portion of the new red sandstone series is generally formed of conglomerate and strata. And, finally, that there is a decided difference between the coal found in the independent formations, and the lignite or brown coal of the more recent deposits.*"

In support of these opinions Dr. M'Culloch expresses himself thus—

"The coal series which have been called independent, forms the great repository of that mineral in Britain, though not the exclusive one; and its leading character is to occupy a geological position superior to the old red sandstone, and inferior to the new one, or to the red marl. . . . . . As the beds of coal are found accompanying and alternating with stratified rocks, so they are also disposed in strata parallel to them. These strata are in every respect analogous, in their forms, dispositions, and accidents, to those of the rocks with which they occur. In position, they are horizontal, or inclined at various angles, often highly elevated, as is the whole series. . . . . The thickness of a coal stratum varies, even from less than an inch, to ten or twelve feet, but it rarely exceeds two or three, and is, more often, much less; and thus particular strata become extenuated till they disappear. . . . . .

"Now, it is essential to remark, that the old red sandstone, the mountain limestone, and the coal series, are all disturbed, being elevated, undulated, and fractured in various ways. . . . . . And it must, similarly, be recollected, that a new order commences with the magnesian limestone, and the red marl; or that they are placed on the coal series, and the inferior strata, in an unconformable position, while the lower substance also presents that conglomerate structure, which everywhere throughout nature accompanies a new order in rocks. Hence the first three deposits have often been united, as forming one class, and as if they had undergone but one disturbance common to the whole. But from the former remarks on this subject, it is plain that the coal series is really distinct, in time and production, from the inferior strata; and hence cannot be always truly conformable to them, though the last general disturbance is common to the whole."*

"It was not enough," observes Professor Buckland, when treating of the carboniferous series, "that these vegetable remains should have been transported from their native forests, and buried at the bottom of ancient lakes and estuaries and seas, and there converted into coal; it was further necessary that great and extensive changes of level should elevate, and convert into dry and habitable land, strata loaded with riches, that would for ever have remained useless,

* Geology, vol. ii. pp. 299—304.

had they continued entirely submerged beneath the inaccessible depths wherein they were formed; and it required the exercise of some of the most powerful machinery in the dynamics of the terrestrial globe, to effect the changes that were requisite to render these elements of art and industry accessible to the labour and ingenuity of man.

"The place of the great coal formations, in relation to the other series of strata, is shown in our first section; and they are represented as having partaken of the same elevatory movements, which have raised the strata of all formations towards the mountain ridges, that separate one basin from another basin. . . . . .

"This disposition in the form of troughs or basins, which is common to all formations, has been more particularly demonstrated in the carboniferous series, because the valuable nature of the beds of coal often causes them to be wrought throughout their whole extent.

"One highly beneficial result of the basin-shaped disposition of the carboniferous strata has been to bring them all to the surface around the circumference of each basin, and to render them accessible by sinking mines in almost every part of their respective areas. An uninterrupted inclination in one direction only, would have soon plunged the lower strata to a depth inaccessible to man."*

"This valuable series of strata, the *carboniferous system*," says Professor Phillips, "to which Great Britain owes so much of her commercial prosperity, is extended irregularly over the basins of Europe, North America, Australia, &c. It occupies large breadths in Scotland, Ireland, England and Wales, and lies in patches in various quarters of France, Germany, Poland, and Russia. Commonly it is found at the foot or on the flanks of primary mountains which had been previously uplifted, so that its stratification is not in accordance with theirs. . . . . .

"The variations in the development of the carboniferous system are considerable, and its occurrence is often in detached portions, it is, therefore, requisite for obtaining a general section, to combine the results of different and independent observers. . . . . . There are *three great formations* included in the carboniferous system, namely, Firstly. *The upper formation, or coal measures;* three thousand feet thick in the North of England, consisting of abundance of sandstone and shales, layers of ironstone, and beds of coal. Of these there are many alternations, constituting a series of many nearly similar terms,

* Bridgewater Treatise, vol. i. pp. 525—527.

usually containing at least the three substances, coal, sandstone, and shale. Scarcely any limestone occurs in this upper coal measure series. . . . . . The coal seams, twenty or thirty in number, amount in all to a thickness of about sixty feet, in a mass of shales and sandstones at least 3,000 feet; . . . . . And, secondly. *The mountain limestone formation*, which is best examined in the North of England. The whole series undergoing great changes, so as to afford northern and southern types applicable to all parts of the mountain limestone formation yet known in Europe."

The author, in continuation, classifies and briefly describes the rocks composing the several *terms* of these types, but we give merely the names—

"'Millstone Grit,' 'Limestone Shale,' and the 'Limestone of Derbyshire,' compose the *Southern* type. The *Northern* type consists of 'Millstone Grit rocks, alternating with Shales,' 'Laminated Sandstones, Coal Seams, Ironstones, Chert Beds, and Limestones,' in various manners, according to the groups." . . . . .

And then follows the third or last of these divisions—

"*The old red sandstone formation*, varying in its character so as to offer little that is really of general application, except its colour and the absence of coal, and rarity of limestone.". . . . .

"This varied series of rocks," Mr. Phillips goes on to say, "shows, in all its parts, the clearest proof of successive deposition; laminæ, beds, strata, whole rocks and groups of rocks are here seen to be generally parallel. It is, however, very true, that in each kind of rock the phenomena indicative of successive deposition are so far different as to admit of definition. . . . . .

"After the deposition of this system, and before at least any considerable proportion of the superjacent rocks was formed, very extensive displacement happened in most parts of the surface of the globe where the carboniferous rocks had been deposited. . . . . . Hardly a known coal tract being exempt from this influence, it would appear that convulsive movements took place of a very general description, so as to affect very large tracts of the surface of the globe. In the British islands, every coal district is disturbed and shaken in every square mile of its breadth by faults ('gauls, slips, troubles, and dykes'), passing in many directions, some of them having a great amount of 'throw,' and consequently affecting the

working of the mines. But these minor effects lose their importance when we contemplate the gigantic disruption of Tynedale, the Penine chain, the Craven fault, the Derbyshire elevation, the fault of the vale of Clwydd, the double anticlinal axis of the coal fields of South Wales, and the parallel one of Namur. . . . . . North of the Tynedale fault, is a depression or throw of 1,000 to 2,000 feet; west of the Penine fault 2,000 to 3,000 or perhaps 4,000 feet under Crossfell; and south of the Craven fault 3,000 feet at least under Ingleborough."*

We shall terminate these interesting and appropriate evidences by a short extract from Mr. Hugh Miller's work on the "*Old Red Sandstone,*" assured that, together, these various quotations are quite conclusive with respect to the subject under immediate consideration:—

"The vegetable remains of the old red sandstone," he observes, "bear but a small proportion to its animal organisms; and from huge accumulations of these last decomposing amid the mud of a still sea, little disturbed by tempests or currents, and then suddenly interred by some widely spread catastrophe, to ferment and consolidate under vast beds of sand and conglomerate, the bitumen seems to have been elaborated. These bituminous schists, largely charged with sulphuret of iron, ran far into the interior, along the flanks of the gigantic Ben Nevis, and through the valley of Strathpeffer. The higher hills which rise over the valley are formed mostly of the great conglomerates, but the bottom and the lower slopes of the valley are occupied by the bituminous and sulphurous schists of the fish bed, &c. . . . . .

"Is it not a curious reflection, that the commercial greatness of Britain in the present day, should be closely connected with the towering and thickly-spread forests of arboraceous ferns and gigantic reeds, vegetables of strange forms and uncouth names, which flourished and decayed on its surface, age after age, during the vastly extended term of the carboniferous period, ere the mountains were yet upheaved, and when there was as yet no man to till the ground!"†

After the perusal of these evidences the mind may be considered to be prepared for entering, with more effect, into the

* Treatise, pp. 100—106, 112, 113.

† Old Red Sandstone, pp. 233, 234.

examination of a very interesting section of geological research. We allude to the several groups up to the chalk inclusive, which unconformably overlie the coal measures. This *latter* being considered by the Dynamical Theory to have been the last, or most recent deposit of the non-rotatory earth, it follows, that all those just mentioned, namely, the New Red Sandstone, the Oolitic, and the Cretaceous groups, are looked upon as having been formed by the *debris* spread abroad by the rotation of the earth around its axis. Before, however, entering upon the investigation of the new red sandstone group, it may be opportune to remind our readers of our former advertency, that the explanation of the nature and origin of the saline deposits, so universally associated with this particular series, is reserved for a future part of this work; it being necessary to explain the formation of the atmosphere, and the manner in which the water was separated from the land, before these saline depositions can be satisfactorily accounted for.

The *thirty-second* Theorem states, "*That the formation called the* NEW RED SANDSTONE GROUP *is considered to be of mechanical origin and of heterogeneous composition; containing different kinds of fossil salts associated with gypsum, and much conglomerate and breccia.*

"*That conjointly with the Oolitic group, it frequently contributes to form extended tracts of level land, having aided in filling up immense hollows on the earth's surface at a time when, or immediately after, this latter had undergone a great and widely-extended revolution in its physical form, and in the condition of its vegetable and animal life.*"

The following are a few of the evidences which may be given in support of these opinions—

"We now arrive," Dr. M'Culloch says, "at the magnesian limestone of the English series, supposed to correspond to the first floetz stratum, to the Alpine limestone, and to the zechstein of foreign geologists, and followed by the later red sandstone, or red marl, agreeing with their variegated sandstone. A new order of arrangement here begins to be observed among the strata, whence we may take a fresh departure. It is not meant to say, that the red marl, much less the associated inferior limestone, is invariably present,

even in Europe where it is known to occur; but if there is any series truly entitled to the character of regularity, as well as universality, using that term in the general sense formerly stated, it is this one. Still, it is proper to remark, that in the red marl series, which is in itself a very complicated one, there is a very irregular recurrence of the different integrant beds."*

And again—

"It is not always possible to distinguish the three red sandstones, except by careful geological investigations, since the mineral distinctions give but little assistance; the alternation of the primary sandstone with gneiss, or other primary strata, is an infallible geological criterion for that rock. With respect to the red marl, the presence of salt is equally infallible; that of gypsum is a good test, if not absolute. Its superiority to the coal series is another, as is its immediate inferiority to the lias limestone. . . . . . The sandstone under review appears to be one of the most generally diffused rocks in nature; and may thus be considered like gneiss, among the deposits commonly called universal. . . . . . But that which distinguishes this deposit (upper sandstones) from all the secondary sandstones, is the presence of rock salt. . . . . . But it is the proper, or even exclusive repository of salt, although the mineral occasionally passes beyond the rigid boundaries, on both sides, so as to appear in the magnesian limestone below it, and in the lias above."†

"These dissimilar conditions of three great divisions of our country," says Professor Buckland, "result from differences in the geological structure of the districts through which our three travellers have been conducted. The first will have seen only those north-western portions of Britain, that are composed of rocks belonging to the primary and transition series; the second will have traversed those fertile portions of the new red sandstone formation which are made up of the detritus of more ancient rocks, and have beneath, and near them, inestimable treasures of mineral coal."‡

A little further on he observe in a note—

"Although the most frequent position of rock salt and of salt springs is in the strata of the new red sandstone formation, which has

* Geology, vol. i. pp. 274, 275.

† Geology, vol. ii. pp. 214, 228.

‡ Brigwater Treatise, vol. i. p. 3.

consequently been designated by geologists as the saliferous system, yet it is not exclusively confined to them. The salt mines of Wieliezka and Silicia are in tertiary formations; those of Cardona in the cretaceous; some of those in the Tyrol in the oolites; and near Durham are salt springs in the coal formations."*

And in another note he adds—

"M. D'Orbiguy's specimens also confirm Mr. Pentland's view as to the analogies between the great limestone formation of the Eastern Cordillera of the Andes, and the carboniferous limestones of England; and as to the great extent also of the red marl, and new red sandstone formations on the continent of South America."†

Professor Phillips states that—

"Even as early as 1791 Mr. Smith found proof of the faults in the coal strata of Gloucestershire and Somersetshire being anterior to the *new red marl*, for the horizontal beds of that formation lie level over the inclined and broken planes of the coal system."

And after going into many interesting details respecting the *new red sandstone system*, some of which we have quoted already, and others are reserved until we come to treat of the *saliferous* deposits associated with these rocks, he says—

"Upon the whole, then, this new red sandstone system is a vast mass of sandy and argillaceous sediments of a peculiar aspect, accompanied more than any others yet known by salt and gypsum, generally deficient in organic remains, and only locally enclosing strata of limestone, which commonly are characterized by abundance of magnesia. . . . . . Metallic veins are, in England, very rarely heard of in these rocks, and nowhere worked. . . . . .

"Several reasons might be adduced to justify an opinion, that the time occupied in the production of the whole system was comparatively short, such as the general uniformity of its composition, the deficiency (except in limited regions) of limestone; the peculiar chemical and mineral character of these limestones; the general paucity of organic remains; the frequency of conglomerates and local admixture of fragments of igneous rocks—all these circumstances seem to indicate the predominance of an unusual series of agencies." . . . . .

* Bridgewater Treatise, vol. i. p. 71. † Ibid, p. 390.

Again, respecting the *oolitic* group, he says—

"The general result of all this is, that the type of the oolitic system of the South of Europe is more calcareous; that of the North of Europe more arenaceo-argillaceous. The former has the air of an oceanic, or deep sea deposit, little disturbed by currents of water; the latter was accumulated under the predominant influence of littoral agitation. In most cases the specially argillaceous formation is distinguishable from the specially calcareous upper oolites; the middle part of the system is the most variable, and the uppermost formation is merely local. . . . . .

"The deposition of the oolitic system seems to have followed upon that of the red sandstone rocks without the intervention of more than local disturbances; and it appears that few such disturbances broke the long uniformity of the periodical agencies exerted in the oolitic period. M. Murchison has shown that the elevation of the granitic mass of the Ord of Caithness, took place after the deposition of most of the oolitic rocks, for these are thrown into great confusion in the vicinity."*

We have a similar conclusion, though in a more descriptive style, from the pen of Mr. Miller, when delineating the characteristic scenery of the several formations.

"Still the traveller passes on," says he, "the mountains sink into low swellings; long rectilinear ridges run out towards the distant sea, and terminate in bluff precipitous headlands. The valleys, soft and pastoral, widen into plains, or incline in long-drawn slopes of gentlest declivity. The streams, hitherto so headlong and broken, linger beside their banks, and then widen into friths and estuaries. The deep soil is covered by a thick mantle of vegetation—by forest trees of largest growth, and rich fields of corn; and the solitude of the mountains has given place to a busy population. He has left behind him the primary regions, and entered on one of the secondary districts.

"And these less rugged formations have also their respective styles—marred and obliterated often by the plutonic agency, which imparts to them in some instances its own character, and in some an intermediate one, but in general distinctly marked and easily recognized. The chalk presents its long inland lines of apparent coast,

* Treatise, pp. 123, 127—129, 134, 135, 140.

that send out their rounded headlands, cape beyond cape, into the wooded or corn-covered plains below. Here and there, there juts up at the base of the escarpment a white obelisk-like stack; here and there, there opens into the interior a narrow grassy bay, in which noble beeches have cast anchor. There are valleys without streams; and the landscape atop is a scene of arid and uneven downs, that seem to rise and fall like the sea after a storm. We pass on to the oolite: the slopes are more gentle, the lines of rising ground less continuous and less coast-like; the valleys have their rivulets, and the undulating surface is covered by a richer vegetation. We enter on a district of new red sandstone. Deep narrow ravines intersect elevated platforms. There are lines of low precipices so perpendicular and so red that they seem as if walled over with new brick; and here and there, amid the speckled and mouldering sandstones that gather no covering of lichen, there stands up a huge altar-like mass of lime, mossy and grey, as if it represented a remoter antiquity than the rocks around."*

In a subsequent part of the same work, when describing what he calls the "platform of death," he asserts—

"The disturbing granite of the neighbouring eminences was not upheaved until after the times of the oolite."†

"The *Red Sandstone Group*," says M. de la Beche, "which is often one of very considerable thickness, succeeds, in the descending order, the oolitic series previously noticed. Perhaps very fine lines of distinction should not be drawn between the two; for when the lower part of the one and the upper part of the other have been considerably developed, they seem, in some measure, to pass into each other. . . . . .

"The rocks composing the red sandstone group occur in the following descending order:—1, variegated marls; 2, muschelkalk; 3 red or variegated sandstones; 4, zechstein; and, 5, red conglomerate, or todtliegendes. . . . . .

"Taken as a mass, the group may be considered as a deposit of conglomerate, sandstone, and marl, in which limestones occasionally appear in certain terms of the series. . . . . . The conglomerates, or todtliegendes, commonly occupy the lowest position, though conglomerates are occasionally noticed higher in the series; the sandstones form the central part, and the marls occur in the highest place.

* Old Red Sandstone, pp. 243, 244.

† Pages 280, 281.

"When we look for the causes which have produced this mass, we may, perhaps, in some measure approach them, by observing the state of the rocks on which it rests. These are found in the greater number of instances highly inclined, contorted, or fractured; evidences of disturbance which the inferior and older rocks have suffered previous to the deposit of the red sandstone group upon them. These appearances are not confined to particular districts, but are more or less general in Western Europe. From an examination of the lower beds, no doubt can exist that the fragments of rock contained in them have, for the greater part, been broken off from the older rocks of the more immediate neighbourhood.

"It, therefore, does not appear unphilosophical to conclude, that, as far at least as regards these lower conglomerate beds, we have approached to something like cause and effect: the cause being the disruption of the strata, the effect being the dispersion of fragments, consequent on this violence, over greater or less spaces by means of water, probably thrown into agitation by the same disturbing forces.

"That these forces have, in some places, at least, not been small, is attested by the large size of the fragments driven off, and the rounded condition of some of them, as may be well seen in the vicinity of Bristol, where the rolled masses of carboniferous limestone are sometimes considerable." (The sectional view of Petit Tor Cliff in Babbacombe Bay, and the explanation given, though too long for insertion here, are very confirmatory, and may, with advantage, be referred to.) . . . . .

"As we can scarcely conceive such a general and simultaneous movement in the inferior strata, immediately preceding the first deposits of the red sandstone series, that every point on which it reposes was convulsed and threw off fragments of rocks at the same moment, we should rather look to certain foci of disturbance for the dispersion of fragments, or the sudden elevation of lines of strata, sometimes, perhaps, producing lines of mountains, in accordance with the views of M. Elie de Beaumont. The accumulation of the larger fragments, and the relative amount of conglomerate, would, under this hypothesis, be greatest nearest to the disturbing cause; and amid such turmoil we might anticipate the occurrence of igneous rocks thrown up at the same period. . . . . .

"But we must now turn from this scene of disturbance, which may be one of the extreme cases, though many analogous facts might be adduced, to that state of things where no violent disrupting cause is to be surmised; but where, on the contrary, the cause

which produced the arenaceous rocks that constitute the upper portion of the next and inferior groups, have not been interrupted by any sudden violence, one series of rocks passing into the other, so that the exact lines of demarcation are imaginary. Such a state of things is perfectly consistent with local and violent disturbances. . . . .

"Between such extremes there would be every variety of deposit produced either by difference in the intensity of the disturbing forces, or by local circumstances. Thus, sands and little or no conglomerate might be found resting unconformably upon older rocks, even in the vicinity of greatly disturbed situations, as may be occasionally observed in the district first noticed.

"After the causes, whatever they were, which produced the conglomerates and sandstones known by the name of *todtliegendes* had, in some measure, been modified, a considerable deposit of carbonate of lime, often charged with carbonate of magnesia, took place over certain parts of Europe. . . . . .

"Viewed in the mass, circumstances appear to have been unfavourable in those parts of Europe which have been best examined, if not to the existence of animal and vegetable life, at least to their envelopment and preservation; for, with the exception of Alsace and Lorraine, few or no organic remains have been detected in it." . . .

And in conclusion on this important subject from this author—

"If we now abstract our attention from these divisions, and regard the group as a mass, it would seem to constitute the base of a great system of rocks, which when not deranged by local accidents has filled numerous hollows and inequalities of land over considerable parts of Europe; such a hollow as will be seen in our own island where the central counties are occupied by the red sandstone series, apparently filling up a previously existing depression in that situation; but it is here without that great capping of the oolitic group, which for the most part rests so conformably upon it, so that taken as a whole, and abstraction being made of minor derangements, they would both seem to fill up great depressions in Europe, sometimes, as is the case in Normandy, the oolitic rocks overlapping and covering and coming in contact with strata older than the red sandstone group, upon which latter they, nevertheless, rest so conformably, that the one seems a tranquil deposit on the other. We must, of course, consider that numerous local disturbances would produce a marked difference in the deposits, even amounting to a perfectly

unconformable position, yet the conformable nature of the two groups, taken in the mass, is somewhat striking. During their deposit great and remarkable changes were effected in animal and perhaps vegetable life.

"It would appear, more particularly from the descriptions of Humboldt, that very extensive tracts of red sandstone and conglomerate exist in Mexico and South America; but how far these may be of contemporaneous production with the red sandstone series of Europe, the state of science does not permit us very accurately to determine. . . . . . A series of red sandstones, intermixed with conglomerates, occur extensively in Jamaica. . . . . . The mere mineralogical resemblance of the deposit, in America and Jamaica, with the sandstones and conglomerates of the red sandstone group of Europe, is, in itself, of no great value; and therefore we can only at present conclude, that considerable forces have been exerted in both parts of the world, whether contemporaneous or not remains to be determined, which have dispersed fragments of pre-existing rocks, scattering them, most probably, by the medium of water violently agitated, in various directions, the transporting powers being unequal, so that sandstones and marls alternate with conglomerates. These sandstones and conglomerates would appear, from the descriptions of geologists and intelligent travellers, to extend from Mexico far into the heart of North America; so that, if different deposits have not been confounded under one head, as it might easily happen in England, if it were an uncultivated country and rapidly examined, the old red sandstone of English geologists being confounded with their new red sandstone, these sandstones and conglomerates of America would appear, not the result of a limited disturbance, but of one common to a considerable surface."*

Mr. Lyell, in accounting for the *origin of the new red sandstone group*, says—

"The red sandstone, and red marl, which in point of thickness, form the most considerable part, both of the upper and lower new red formation in England and Germany, may have arisen in great part from the disintegration of various crystalline or metamorphic schists; and sometimes, as in parts of Saxony and Devonshire, from porphyritic trap rocks, containing much oxide of iron. . . . . . The pebbles of gneiss in the tertiary red sandstone of Auverne,

* Manual, pp. 390, 400, 403—405, 408—412.

point clearly to the rocks from which it has been derived. The red colouring matter may have been furnished by the decomposition of hornblende or mica, which contain oxide of iron in a large quantity.

"It is a general fact, and one not yet accounted for, that scarcely any fossil remains are preserved in stratified rocks in which this oxide of iron abounds; and when we find fossils in the new or old red sandstone in England, it is in the grey, and usually in the calcareous beds that they occur."*

This brings us briefly to consider the last two geological groups of continuous formation, which are supposed by this theory to have been deposited from the *debris* of the world's rocky crust when it was first put into rotatory motion; and which materially assisted to fill up the hollows occasioned by the elevation of its mountain chains. They are referred to in the *thirty-third* Theorem, which states, "*That whatever may have been the nature and extent of the revolution, alluded to in the preceding theorem, as having affected the earth's surface, it and its attendant circumstances seem to have exercised a direct and material influence over the widely-extended deposits, the 'Oolitic' and the 'Cretaceous Groups.' The Chalk formation being considered the most recent of the secondary series; after whose deposition there appears to have taken place a manifest change in the state and condition of our planet, and also in its vegetable and animal existences.*

The evidences supporting those opinions are the following:

M. de la Beche, when treating of the classification of rocks, has the following passage:—

"Subsequently, from observations made by MM. Cuvier and Brongniart on the country around Paris, a fourth class was instituted, and called tertiary, *because the strata composing it occurred above the chalk, a rock considered as the highest of the secondary class.*"

And when describing the cretaceous formation, he says—

"The upper portion of the cretaceous group partakes of a common character throughout a large portion of Western Europe, generally presenting itself under the well-known form of chalk. . . . .

* Elements, vol. ii. pp. 102, 103.

The white chalk, when freed from the flints or siliceous grains mixed with it, is found to be a nearly pure carbonate of lime; containing in 100 parts, carbonate of lime 98, magnesia and a little iron 1, and alumina 1. . . . . . Without entering further into the smaller divisions of the cretaceous group, it may be remarked, that the whole taken as a mass, may, in England, and over a considerable portion of France and Germany, be considered as cretaceous in its upper part, and arenaceous and argillaceous in its lower part. . . . . . This group is extensively distributed over Europe. . . . . .

"Having premised thus much respecting the geographical distribution of the cretaceous group, we will give a slight sketch of the variations in its mineralogical character. Throughout the British Islands, a large part of France, many parts of Germany, in Poland, Sweden, and in various parts of Russia, there would appear to have been certain causes in operation, at a given period, which produced nearly, or very nearly, the same effects. The variation in the lower portion of the deposit seems merely to consist in the absence or presence of a greater or less abundance of clays or sands, substances which we may consider as produced by the destruction of previously existing land, and as deposited from water which *held such detritus in suspension*. The unequal deposit of the two kinds of matter would be in accordance with such a supposition. But when we turn to the higher part of the group, into which the lower portion graduates, the theory of mere transport appears opposed to the phenomena observed, which seem rather to have been produced by deposition from a *chemical* solution of carbonate of lime and silex, covering a considerable area. . . . . . No springs or set of springs, which we can imagine, are likely to have produced this great deposit of chalk, so uniform over a large surface. But although springs, in our acceptation of the term, could scarcely have caused the effect required, we may, perhaps, look to a greater exertion of the power which now produces thermal waters, for a possible explanation of the observed phenomena. . . . . The deposits arising from which have overlapped a great variety of pre-existing rocks, from the gneiss of Sweden to the Wealden deposits of south-eastern England inclusive. . . . . .

"M. Elie de Beaumont endeavours to show, that violent disruptions of strata, in different situations, have preceded the deposit of the cretaceous group; and he infers this from the tranquil position of deposits of this nature on the upheaved beds of more ancient rocks. . . . . . Supposing this theory probable, we might ask how

far it would assist us in explaining the chemical character of the white chalk and flints, &c."

And further on he observes, with respect to the *Wealden rocks*—

"Some cause, with which as yet we are imperfectly acquainted, subsequently produced a great change in the relative levels of sea and land, and the cretaceous rocks, chalk, and green sand, became deposited over a very considerable area, one apparently extending over a much larger superficies than that in which the last formed rocks of the oolitic series were deposited."

And lastly from M. de la Beche—

"The student will have collected from the foregoing pages, as indeed is also remarked by Professor Sedgwick, that there was in Europe, no important change in the general zoological character of deposits up to the Zechstein inclusive; the first great alteration, as far as we can at present see our way, being observed in the remains entombed in the variegated sandstones (gres bigarrê), and muschelkalk."*

Mr. Lyell thus expresses himself regarding the *origin of white chalk*—

"Having, then, come to the conclusion, that the chalk was formed in an open sea of some depth; we may next enquire, in what manner so large a quantity of this peculiar white substance could have accumulated over an area many hundred miles in diameter, and some of the extreme points of which are distant, as we shall see in the sequel, more than 1,000 geographical miles from each other. . . . . . It had been often suspected, before these discoveries, that white chalk might be of animal origin, even where every trace of organic structure has vanished. . . . . But this bold idea seemed to many naturalists a vague and visionary conjecture, until its probability was strengthened by new evidence brought to light by modern geologists.

"We learn from Lieut. Nelson, that, in the Bermuda islands, there are several basins or lagoons almost surrounded and enclosed by reefs of coral. At the bottom of these lagoons a soft white calcareous mud is formed by the decomposition of *eschara*, *flustra*,

* Manual, pp. 33, 259—267, 310, 520.

cellapora, and other corallines. This mud, when dried, is undistinguishable from common white earthy chalk. About the same time Mr. C. Darwin observed similar facts in the coral islands of the Pacific; and came also to the opinion, that much of the white soft mud found at the bottom of the sea, near coral reefs, has passed through the bodies of worms and intestines of fishes; certain gregarious fishes of the genus *sparus* being visible through the clear water browsing quietly in great numbers, or living like grazing herds of gramniverous quadrupeds. On opening their intestines they were found to be filled with impure chalk. This circumstance is the more in point, when we recollect how the fossilist was formerly puzzled by meeting, in chalk, with certain bodies, called *cones of the larch*, which were afterwards recognized by Dr. Buckland to be the excrement of fish. . . . . .

"The area over which the white chalk preserves a nearly homogeneous aspect is so great, that geologists have often despaired of finding any analogous deposit of recent date; for chalk is met with in a north-west and south-east direction, from the North of Ireland to the Crimea, a distance of about 1,140 geographical miles, and in an opposite direction it extends from the South of Sweden to the South of Bourdeaux, a distance of about 840 miles. But we must not conclude that it was ever uniformly spread out over the whole of this vast space, but merely that there were patches of it, of various sizes, throughout this area.

Now, if we turn to those regions of the Pacific over which coral reefs are scattered, we find some archipelagos of lagoon island, such as that of Dangerous Archipelago for instance, and that of Radack, and some adjoining groups, which are from 1,100 to 1,200 miles in length, and 300 to 400 miles broad; and the space to which Capt. Flinders proposed to give the name of Corrallian Sea is still longer; for it is bounded on the east by the Australian barrier, on the west by the New Caledonian, and on the east by the reefs of the Louisiade. Although the islands in these spaces may be thinly sown, the mud of the decomposing zoophytes may be scattered far and wide by the oceanic currents." . . . . .

And when accounting for the *Greensand formation*, he says:

"Unlike the white chalk, this deposit consists of a succession of ordinary beds of sand, clay, marl, and impure limestone, the materials of which might result from the wearing down of the preexisting rocks." . . . . .

With respect to the geological position of the chalk, this same author, in a previous part of his work thus expresses himself:—

"We come now to the consideration of a class of fossiliferous formations, called 'tertiary' which are immediately antecedent in the order of time to the post-pliocene deposits already treated of. The name of tertiary has been given to them, because they are posterior in date to the rocks termed 'secondary,' of which the chalk constitutes the newest group."

In the sequel of "The Elements of Geology," Mr. Lyell enters into a detailed explanation of the manner in which it is considered that the chalk and its associated formations—firestone, gault, lower greensand, weald clay, and Hastings sands, were brought into their present position in the Weald district, by the powerful denuding action of water, during the period of their being upheaved; and he calls in the aid of his distinguished contemporary labourers, Messrs. Mantell and Martin, to confirm these opinions; while he also appeals for their corroboration to Mr. Hopkins's mathematical investigations. Unfortunately these passages, which contain so much detail, are too long to admit of being inserted here, and we must, therefore, refer our readers to Mr. Lyell's work itself, which we do with much pleasure.*

Professor Phillips observes—

"It is found by actual observation, that the chalk, which is the lowest mass of strata noticed in the vicinity of London, is continuous with and forms part of that chalk which is at the top of the Oxfordshire series. It is also found that this same chalk is actually traceable, with little interruption, in a very clear and satisfactory manner, from Oxfordshire into Yorkshire, where also it forms the top of the section; that the oolitic rocks, the blue clays and limestones, the red clays and red sandstones, are in the same way continued from Oxfordshire to Yorkshire. The same stratified rocks then occur in very distant situations in the same order of succession, having certain rocks above them. If, now, we compare the Cambrian and Scottish series of rocks, we shall find several common terms in similar

* Vol. i. pp. 391—404, et seq., and vol. ii. pp. 2—38.

parts of the series, and thus be able to unite all the five sets of observations into one general view.

"The continuity of the strata near to the surface of the earth, and the constancy of their order of succession, being thus shown to be susceptible of exact proof, they are unequivocally established." . . .

And again—

"The cretaceous system is unconformed to the oolites at only two points in England, viz.—in Yorkshire and Derbyshire; and round the basin of Paris and in the south of France the same conformity of the two systems is found to prevail. It thus becomes easy to trace the boundary of the cretaceous rocks by referring to the outline of the oolites. The chalk and its associated beds pass from Yorkshire through Lincolnshire, Norfolk, Suffolk, Hertfordshire, Bedfordshire, Buckinghamshire, Oxfordshire, Wiltshire, to Dorsetshire, always presenting a noble front of rounded hills to the west and north-west. Thence they return to the east through the Isle of Purbeck and the Isle of Wight, the broad inland surfaces, which are included between the Isle of Wight and the Hertfordshire hills, being formed into two parallel synclinal troughs, the vales of London and of Hampshire, separated by one great anticlinal axis, passing from Wiltshire to the coast of Kent, and continued into France in the district of Boulogne. The anticlinal axis alluded to changes through Sussex into a great denudation, or valley of elevation, exposing the wealden formation in the centre, with escarpments of the cretaceous system on the north, south, and west in England, and on the east in France. Hence, in general terms, we may say the chalk of England is distinctly related in escarpments and slopes to the present German Ocean, and the eastern part of the English Channel. . . . . .

"In France, the cretaceous system, commencing at Calais, sweeps in a vast circle round Paris by Lille, Chalons, Troyes, Saumur, and Le Mans, to the embouchure of the Seine; thus appearing as a great southward branch of the English chalk system, formed in a bay of the then ocean, which was defined between the mountains of Brittany, La Vendee, Auvergne, the French Jura, and the Ardennes. From this great area (principally chalk) a broad expanded but mostly subterranean mass of cretaceous strata extends along the north side of the Ardennes and the valley of the Meuse, and continues along the northern border of high ground in Germany, from Essen to Paderborn, turning as that border turns to Osnaburg, and then returning through Hanover and Brunswick. It reappears along

the range of the great tertiary plains which stretch to the north into Russia, and to the east to the Black Sea. In Denmark and Scania and along the Baltic (Isle of Rugen) chalk occurs in its usual character. Along the northern and southern flanks of the Alps some beds of the cretaceous system range extensively. Along the Pyrenees, the chalk system is very fully developed, and has been uplifted to great elevations by disturbances of comparatively recent date. In the south of Spain also chalk with flint occurs. In America, rocks of the cretaceous period are abundant along the eastern side of the United States, particularly in New Jersey, along the coasts of the Carolinas, in Georgia, Florida, and Alabama, true chalk, however, being wholly unknown or at least very rare. . . . . .

"The most characteristic deposit, as along the Alps, being greensand, associated with limestones, compared to oolites in New Jersey, having a more chalky aspect in Florida and Alabama, where it assumes important features, but without real chalk or true flints."

And in conclusion, from Professor Phillips—

"It is rendered evident that the English type is more or less applicable to the greater portions of the earth's surface where the cretaceous system has been recognised; that the lower parts of the system are generally sandy, the upper parts often calcareous, but that the development of those two groups is not proportional nor depending on the same centres of influence. In the north of Europe the upper group seems generally to predominate, but in the middle of Europe the greensand system is more expanded and regular; in the northern parts of the United States the greensand abounds, in the southern calcareous rocks are more important. Yet upon the whole it must be granted, that the agencies concerned in producing the cretaceous system were more extensive and uniform than those by which the oolites were accumulated.

"Two formations are almost universally admitted as constituting the cretaceous system.

"*The chalk formation*, named from the most characteristic mineral substance; thickness 600 feet. It includes the following groups: Maestricht beds, upper or flinty chalk, middle or hard chalk, lower chalk or chalk marl.

"*The greensand formation*, commonly abounding in a green silicate of iron; thickness 600 feet. It includes upper greensand, &c., golt or blue marly clay, lower green or iron sand, with beds of sandy or chalky limestone. . . . . .

"The tertiary strata have, in general, to the chalk the same geographical relations as that to the oolites. Throughout England, the chalk is the base of all the tertiary strata. In France this is generally the case, and almost universally so for the marine tertiaries. In the North of Germany, along the north and south slopes of the Alps, and in the basin of the Danube, this is at least very extensively true. In North America, the general basis of the tertiaries is the cretaceous formation. On more close enquiry, it appears, however, that the tertiary strata are seldom exactly conformed to the stratification of the chalk; that anything like a gradation or alternation of the cretaceous into tertiary deposits, is rarely known; that the organic remains of the one group differ almost wholly and absolutely, except in the South of France, at Maestricht, &c., and constitute two distinct groups of created life. Hence it has become a popular opinion, that with the secondary strata ended a certain general condition of the globe, and with the tertiaries commenced a totally new arrangement. Moreover, because we find the marine tertiary strata distinctly related, in geographical expansion, to the present basins and arms of the ocean; as the organic remains which they contain are similar, and, in rocks of later date, identical to those of the existing races in the sea and on the land; and as the tertiary sediments are of a nature very analogous to the daily products of the sea, estuaries, tide-rivers, and lakes, there is but a step further to unite the tertiary era with the historical period of the globe, and to place the commencement of the actual creation or arrangement of organic nature at the epoch immediately following the chalk."*

As final evidence on this particular point, we give the following quotation from Mr. Ansted's work:—

"Over a large part of the known world, the close of the first epoch, marked by great subsidencies of land, by the swallowing up of continents and islands into the sea, and by accompanying violent dislocations of the stratified crust of the globe, was of necessity accompanied by the re-distribution of these fractured materials of strata; and, owing no doubt to the great amount of trituration, the beds thus formed contain but few remains of organic beings. These, however, indicate the commencement of the new era. The presence of the new red sandstone, a formation consisting of sand and marl,

* Treatise on Geology, pp. 33, 149, 153, 161, 162.

with rare local interpolations of limestone, characterises this epoch; and, after this, until towards the close of the secondary or middle period, we find few intermediate beds over the whole of America; and the same is the case with regard to the greater part of Asia and Australia, as far as geologists have yet been able to determine. . . .

"The deposit of sand and marly beds, which must have been steadily continued for a long time over extensive tracts at the commencement of the secondary period, seems to have gradually changed to a finer, more calcareous, and less sandy mud thrown down from suspension in water, perhaps after it had been carried for some distance by marine currents. This deposit of mud was local, since, so far as we can tell by examining the tracts now above water, it was almost confined to a part of England and a narrow tract in the middle of Europe, though it has been thought traceable in the middle of Asia, as it is possibly represented in a small part of South America. The bed is sometimes more or less sandy or calcareous; but we know of few contemporaneous deposits; and where the muddy beds do not appear, there is often nothing intermediate between the new red sandstone and the newest beds of the middle epoch. . . . . .

"After the termination of that great deposit of calcareous mud, so characteristic of the older part of the middle secondary period, considerable change seems to have taken place in the relative position of land and sea; and, from the abundance of calcareous rock afterwards developed, as well as from the nature of the fossils, it may safely be concluded that these changes involved important alterations in the whole system of organic nature in this part of the world. Referring only to those districts which, being now land, enable us to discover their structure, and drawing our conclusions only from the actual facts that have been determined, we may venture to conclude, that, immediately after the deposit of the lias, the bed of the sea was affected by widely acting earthquake movements, and that tracts of land, more or less extensive, rose up, especially on the north-eastern flank of the lias in Yorkshire, in several districts on the continent of Europe, and in the central and eastern portions of North America."

And again, further on, he continues—

"The close of the secondary period was succeeded by a general disruption of the various beds that had been deposited in those parts of the earth to which we now have access, and by changes and mo-

difications so considerable as to alter the whole face of nature. It would appear, also, that a long period of time elapsed before newer beds were thrown down, since the chalky mud not only had time to harden into chalk, but the surface of the chalk itself was much rubbed and worn. So completely and absolutely is the line of demarcation drawn between the secondary and newer deposits, in parts of the world where these beds have been recognized in actual contact, that it had become a common notion amongst geologists, to assume the destruction of all natural relations between them, concluding that not one single species of animal or vegetable connected the two periods, and lived through the intervening disturbances. Although this view certainly requires modification in points of detail, it is still correct in a general sense, and expresses, without much exaggeration, the real extent of difference in condition, the result, perhaps, a lapse of time greater than is elsewhere indicated. In this way the secondary period is distinctly cut off from the tertiary. It is scarcely less separated by the fact, that in the former we everywhere find marks of the presence or near vicinity of the sea in all the deposits, even those from fresh water, while, in the newer beds, land animals at once assume the importance which they have ever since retained, having been evidently present in great numbers and variety. . . . . We have to enter upon a new series of phenomena, when we turn from the contemplation of the secondary to that of the tertiary period. When, however, the time had elapsed, and the change had taken place, and it must be repeated, that the interval, whether long or comparatively short, was marked by the destruction of nearly the whole marine creation; when, after this, the sea bottom in these parts of the world again received accumulations of mud and shingle, it is not unlikely that a great elevatory movement had already commenced. From the general direction of the subsequent disturbances which brought to light the Wealden district in England, and elevated the Alps and the Caucasus, it is almost certain that the line of that movement was, on the whole, east and west."*

According to the order in which geological phenomena are usually classed, we come now to take a hasty view of an interesting suite of formations; which, from some peculiarities, in the manner of their colocation, have been styled *tertiary*, in contradistinction to the *primary* and *secondary* divisions.

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* Ancient World, pp. 115, 135, 183, 265, 266.

They are situated in detached groups surrounded by the other two classes, without appearing to have been affected by them, although, in many instances, they are indebted to them for the basins in which they exist; while they afford evident symptoms of having been deposited from a mass of finely comminuted material.

The sudden manner in which it is considered, by this theory, that the primeval water, bearing the mass of debris, was separated from the dry land, by *evaporation*, prevents us from acknowledging the whole of the tertiary suite as the result of the commotions which took place amongst the rocky masses, and of the rush of water from the polar towards the equatorial regions, occasioned by the earth's first rotation. On the contrary, we are constrained, by our principles, to look to another and more recent cause for the origin *of the newer or upper portion* of those tertiary deposits; feeling confident, that a more critical examination will reveal, in the very formations themselves, a well marked boundary line between the phenomena originating from the first rotation of the earth around its axis, and those which accompanied a much later and less auspicious event. It is presumed, that in the circumstances attending the subsiding of the water of the Noachean deluge may be found an adequate explanation of the *upper* part of the tertiary strata. However tranquilly and slowly that water of wrath and punishment may have risen upon and overwhelmed its victims; and however slight may have been its effects upon the more prominent geological and geographical features of the world, there can be as little doubt, according to the testimony of Scripture,* that, when it began to assuage, it was kept, by the continual action of wind, in a state of agitation for wise and provident purposes. This violent movement, while intended to accelerate evaporation, would, by causing comminution and the washing away of the softer soils, impregnate the water, as it subsided, with earthy sediment. This earthy sediment, evidently much more pulverised than the debris occasioned by the first rotation, would, on subsiding, entomb the accumulated remains of those creatures in whom had been

* Genesis, viii. 1.

the breath of life, when the living principle, with but little exception, was extinguished upon the face of the earth, and thereby rid its future inhabitants of the pestilence which so much putrid animal matter would, otherwise, have occasioned.

As we intend at a future period to enter fully into this department of geological research, and to offer some explanations, we make only this passing allusion, while we shall revert, for the present, to our more immediate argument; and by way of preparing the mind for what may follow, we subjoin the Theorem and evidences referring to the tertiary strata; although we shall refrain from offering any further remarks until the sequel of our treatise, whose object it will be to endeavour to explain these geological phenomena. Meanwhile, we trust, that the care of defining, with precision, the boundary line which separates the formations due to dynamical causes, from those which resulted from the Noachean Cateclism, will occupy the attention of some zealous and unprejudiced advocate of the truth.

Our object, in this part of our discourse, having been, and we trust we have satisfactorily accomplished it, to account for the enormous mass of *mineral debris* which was scattered abroad, when the disruption of the strata took place by the bursting through of the subjacent rocks; and whose extent of surface, it may be remembered, was estimated on a moderate computation, at *three millions seven hundred and fifteen thousand square miles;* some estimate of the mineral contents of this vast area may be formed when it is considered, that it has to be multiplied by the thickness of the accumulated strata of which it was composed! Did there exist no suites of formations reposing unconformably upon the older and elevated stratified masses; spreading themselves over widely extended areas, and filling up hollows on the earth's more recent geological outline, we should not have known where to have sought, or how to have accounted for the immense mass of mineral matter which this theory presupposes to have been disrupted and spread abroad at that particular juncture. The existence, however, of strictly corresponding formations, relieves our anxiety on this point, and fully confirms the theory. How they may be satisfactorily accounted for, with all

their concomitant circumstances, independently of the Dynamical Theory, we are somewhat at a loss to conjecture, and must, therefore, leave it to others, should they think proper to endeavour to give the required explanation.

The *eighteenth* Theorem, alluded to, is to the following effect—"*That in contrasting the secondary with the tertiary formations, a marked difference is observable in many respects between them; the former being generally more continuous in their series and more equal in mineralogical character than the latter, and especially than their more recent portions, which are found situated in detached basins surrounded by primary and secondary formations, in very many instances without either being deranged or altered by them.*"

Professor Buckland states that—

"The tertiary series introduces a system of new phenomena, presenting formations in which the animal and vegetable life approach gradually nearer to species of our epoch. The next striking feature of these formations consists in the repeated alternations of marine deposits with those of fresh water.

"We are indebted to Cuvier and Brongniart for the first detailed account of the nature and relations of a very important portion of the tertiary strata, in their inestimable history of the deposits above the chalk near Paris. For a short time, these were supposed to be peculiar to that neighbourhood; further observation has discovered them to be parts of a great series of general formations, extending largely over the whole world, and affording evidences of at least four distinct periods, in their order of succession, indicated by changes in the nature of the organic remains that are imbedded in them. . . . . . M. Deshayes and Mr. Lyell have recently proposed a fourfold division, of the marine formations of the tertiary series, founded on the proportions which their fossil shells bear to marine shells of existing species. To these divisions Mr. Lyell has applied the terms eocene, miocene, older pliocene, and newer pliocene; and has most ably illustrated their history in the third volume of his 'Principles of Geology.'

"The term eocene implies the commencement or *dawn* of the existing state of the animal creation; the strata of this series containing a very small proportion of shells referable to living species. The calcaine gossier of Paris, and the London clay, are familiar examples of this older tertiary, or eocene formation.

"The term miocene, implies that a minority of the fossil shells in formations of this period, are of recent species. To this era we referred the fossil shells of Bourdeaux, Turin, and Vienna.

"In formations of the older and newer pliocene, taken together, the majority of the shells belong to living species; the recent species in the newer being much more abundant than in the older division."*

Professor Phillips says—

"Without in the least wishing to intimate, that the influence of fresh water in accumulating the materials of the strata is most conspicuous in the newer strata, an inference not justifiable by the facts, it is to be remarked, that the deposition of stratified rocks in limited basins of fresh water is a phenomenon almost characteristic of the tertiary period. . . . . .

"It is evident, from comparing the sections given, that no special resemblance of the strata in thickness or mineral composition can be traced, such as we have found to be frequently observable while examining the older strata. All are composed principally of calcareous, arenaceous, and argillaceous matter, but so are the secondary strata. We do not find in the different regions compared any settled order of succession among the rocks of different nature. The English series has no marine limestone; the Parisian no thick marine clays; the sub-appennine deposits have little arenaceous matter. It is apparent, in fact, that the tertiary deposits vary as to their mineral composition, very much more in relation to locality than to geological time; a fact which at once subverts all hope of arranging them in geological chronology, by comparison of their mineral constitution. It also leads us to infer that the deposition of tertiary strata took place in arms and gulfs of the sea, which ramified among the masses of land then raised in Europe, and derived sediment of different nature from these different lands. Hence the sub-alpine tertiaries have one character; those of the sub-appennines another; the sub-pyrenean a third; the Parisian a fourth; the English a fifth.

"By prosecuting this research, we find, in fact, that the tertiary formation was sometimes produced in insulated seas, like the Adriatic, and the valleys of the Rhine and Danube; at other times, under the influence of the general ocean, as those in the plains of the Garonne, often in basins like the Parisian series."*

* Bridgewater Treatise, vol. i. pp. 76—78. † Phillips, pp. 163, 178.

M. de la Beche says—

"Prior to the labours of Messrs. Cuvier and Brongniart on the country round Paris, the various rocks comprised within the supra-cretaceous (tertiary) groups were geologically unknown, or were considered as mere superficial gravels, sands, or clays. Subsequent to the publication of their memoirs (1811), it has been found that the geological importance of these rocks is very considerable, and that they occupy a large part of the superfices of the present dry land, entombing a great variety of terrestrial fresh water and marine remains."

Regarding the organic remains, he observes—

"The present theory seems to be, that though certain shells may not be precisely peculiar to certain beds, they are more abundant in them than in others, and that the uniformity of organic contents is greater as we descend in the series of fossiliferous rocks; so that the older the beds, the greater will be the uniformity over considerable spaces; and the newer the series, the less the uniformity."

With reference to the insulated character of these tertiary deposits in basins, he says—

"We also hear of the Isle of Wight basin, as if there had existed a separate cavity or depression in that particular place; while there is very good reason for supposing, as has been stated by Professor Buckland, that the supra-cretaceous deposits of London and the Isle of Wight have once been continuous, but that this continuity has been destroyed by the upheaving of the chalk beneath, subsequent to the deposit of these rocks; and that the upraised intervening portion has been removed by denudation, as has happened to much thicker and harder rocks. The same with the Paris basin, which may easily have been connected with those above-mentioned, and as easily separated from them, by movements of the earth, and by denudation. . . . . .

"It may therefore have happened," he further states, "that these so called basins were formerly continuous portions of one whole, which various circumstances have disunited, perhaps even during the deposit of the rocks in question; their commencement having been in a sea which washed the older strata, and extended from the West of Europe, between Scandinavia and Northern Germany, towards the Black Sea."

In continuation, M. de la Beche says—

"Now, all the terrestrial animals found in caves and superficial gravels, marls, and sands, whatever may be the theory formed to account for their disappearance, must have lived upon lands existing at the period under consideration (the supra-cretaceous); and even supposing them in a great measure destroyed by a catastrophe, there is nothing to prevent their having been abundantly entombed during their residence on the earth. The nearer also, judging from organic remains, that the climates can be considered like those now existing, the greater would appear the probability that the rocks containing them occupied the higher part of the supra-cretaceous series."*

"If," says Mr. Lyell, "we take a handful of quartzose sand, mixed with mica, and throw it into a clear running stream, we see the material immediately sorted by the water, the grains of quartz falling almost directly to the bottom, while the plates of mica take a much longer time to reach it, and are carried farther down the stream. At the first instant the water is turbid, but immediately after the flat surfaces of the plates of mica are seen alone reflecting a silvery light, and they descend slowly, to form a distinct micaceous lamina. . . . . . It is easy, therefore, to conceive how the intermittent action of waves, currents, and tides may sort the sediments brought down from the waste of a granitic country, and throw down the mica, layer after layer, separately from the mud or sand. . . . .

"Patches of 'tertiary' strata," he continues, "some of fresh water, others of marine origin, have been observed in various parts of Europe, their geographical extent being usually small, as compared to the secondary formations, and their position often suggesting the idea of their having been deposited in different bays, lakes, estuaries, or inland seas, after a large portion of the European area had already been converted into dry land. They all agree in containing organic remains, which make upon the whole a nearer approach to the generic and specific types of the living creation, than to the fossils of the secondary rocks."

And further on, entering more into particulars, he says—

"The accompanying map," (to which we beg reference), "will explain the position of the principal eocene formations (tertiary) of England, the Netherlands, and France. Those of England, it will

* Manual, pp. 192, 193, 197, 199.

be seen, are confined to two districts, usually called the basins of London and Hampshire. These tracts are bounded by rising grounds, composed of chalk, except where the sea intervenes. That the chalk passes beneath the tertiary strata as represented in Figure 163, p. 387, we not only infer from geological data, but can prove by numerous artificial sections at points where railways have been cut, wells sunk, or borings made through the overlying beds. . .

"The area which has been called the Paris basin is about 180 miles in its greatest length from north-east to south-west, and about 90 miles from east to west. This space may be described as a depression in the chalk, which has been filled up by alternating groups of marine and fresh water strata." . . . . .

When treating of the *general arrangement and origin of the fresh water formations of Auvergne*, he exemplifies them by observing—

"We may easily conceive a similar series of events to give rise to analogous results in any modern basin, such as that of Lake Superior, for example, where numerous rivers and torrents are carrying down the detritus of a chain of mountains into the lake.

"The transported materials must be arranged according to their size and weight, the coarser near the shore, the finer at a greater distance from the land; but in the gravelly and sandy beds of Lake Superior no pebbles of modern volcanic rocks can be included, since there are none of these at present in the district. If igneous action should break out in that country, and produce lava, scoriæ, and thermal springs, the deposition of gravel, sand, and marl might still continue as before; but, in addition, there would then be an intermixture of volcanic gravel and tuff, and of rocks precipitated from the waters of mineral springs." . . . . .

The following passage confirms what has been given, by a different line of proof, namely, organic remains:—

"The *Catillus* may be pointed out as a form which, so far as our present information extends, became extinct at the close of the cretaceous period, being never met with in any tertiary stratum, or in a living state. Among other equally conspicuous forms of fossil mollusca belonging to the cretaceous group, and foreign to the tertiary and recent periods, may be mentioned the *Belemnite*, *Ammo-*

nite, *Baculite*, and *Turrilite*, of the family *Cephalapoda*, to which the living Cuttle-fish and Nautilus belong."*

"Of all the classes of aqueous deposits," observes Prof. Phillips, "that which is the nearest to our own days in point of date is the least exact in its boundaries and characters. While, concerning the older periods, the problem of the condition of the globe was principally confined to considerations relating to the sea, and thus the phenomena could be investigated according to fixed principles, applicable to at least the greater number of strata; the tertiary deposits compel us to enter also upon more complicated researches connected with the land; and, in discussing the history of still later phenomena, all the variations of physical geography assume still higher degrees of importance. The consequence is an amount of local diversity so great as to nearly annihilate all generality of result. Moreover, the difficulties of this subject are augmented by a circumstance which is likely to become daily more and more influential on geological reasoning:—the want of a principle upon which to define the limit of least antiquity of this group of strata. What, in fact, is meant by supra-tertiary deposits? If we substitute for this term modern aqueous products, do we understand it the better? or, attempting analysis, if we adopt as an equivalent expression the diluvial and alluvial accumulations, how are these to be defined? It is evident that here is a serious embarrassment. What is meant by tertiary strata? If we should venture to include in this title all really marine deposits posterior to the chalk, even such as were only yesterday raised from the bed of the sea, it would be more intelligible than the methods now followed by geologists. For with the tertiary strata of Europe begins that extreme *analogy* of the specific forms of organic life, that *identity* of generic conformation, which at once announces great and general differences of physical condition between them and the older strata, and equally great resemblances to the present order of things. "Such results apply to marine, fresh water, and terrestrial life; and, as far as yet appears (but the evidence is very incomplete), nearly in an equal proportion to each." . . . .

He further observes—

"Assuming, for the moment, that the conclusion of the gradual

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* Lyell's Elements, vol i. pp. 31, 32, 270, 336, 346, 377, 387.

change from the oldest tertiary to the actual phenomena produced in the interval from the date of the cretaceous deposits to the present era, may be ranked in one great system, like those adopted for earlier periods, where shall we place the point of union between the modern or historical, and the ancient or geological scales of time? In other words, to what part of the supra-cretaceous period shall we refer the creation of man? To this important question impartiality must allow, that geology gives no clear and certain answer. Geology has no evidence on the subject that is at all of a positive character. We believe that the older stratified rocks were preadamitic for four reasons; because no trace of man or his works have ever been seen in them; because no remains of animals and plants occur in them which can be considered the same, or very similar to the existing forms of life; because land quadrupeds generally are almost utterly unknown in them; because the physical conditions of the globe were entirely different from what we now behold. . . . . .

"It is evident," he goes on to say, "that all the probabilities point to the conclusion, that the creation of man, and all the new arrangements connected with that event, are to be placed in some part of the supra-cretaceous period; but in what part is to be determined by further and cautious research." . . . . .

And in conclusion, from Professor Phillips—

"As far as direct observation or satisfactory inference goes, every honest geologist will allow that he is ignorant of the point of union between the historical and geological scales of time; that the era of human existence, if recorded in geological monuments, has not yet been discovered among the small number which have been fully deciphered."*

Before we close the evidence for this particular branch of our subject, we would take occasion to submit to our readers, the dictum respecting it of one of the most scientific and indefatigable of our British geologists:—

"The grand fact of *an universal deluge*," Dr. Buckland observes, "at no very remote period is proved on grounds so decisive and incontrovertible, that had we never heard of such an event from Scripture, or any other authority, geology, of itself, must have called in

* Treatise on Geology, pp. 190—193.

the assistance of some such catastrophe, to explain the phenomena of diluvian action which are universally presented to us; and which are unintelligible without recourse to a deluge exerting its ravages at a period not more ancient than that announced in the book of Genesis."*

On the same line of proof we have the following confirmatory evidence by Professor Henslow:—

"The history of vegetation could not be completed without some enquiry respecting those plants which existed on the earth in its primeval state, during the extended geological epochs which elapsed before the establishment of the present order of things. . . . . . It was soon remarked, when the study of fossil vegetables began to attract the attention of botanists, that those from the coal measures were distinct from the plants now existing on the surface of the earth; . . . . . that the species embedded in different strata likewise differ from each other; and that, on the whole, there are about fourteen distinct geological formations in which traces of vegetables occur. . . . . .

"It is remarkable that scarcely any species has been found in more than one distinct formation, and none has occurred in any two which are separated by a long epoch. Hence it appears to be a natural conclusion, that there have been successive creations and destructions of distinct species. Mons. Brongniart has grouped the several formations, in which vegetable remains are found, under four great epochs, during each of which no very marked transitions occur in the general character of the vegetation; but between any two of these epochs, a striking and decided change takes place; even most of the genera are different, and none of the species are alike. These epochs include the periods during which the following strata were deposited—1st. 'From the earliest secondary rocks to the uppermost beds of the coal measures;' 2nd. 'The new red sandstone formation;' 3rd. 'From the lowest beds of the oolitic series to the chalk inclusive;' and, 4th. 'The beds *above* the chalk.' . . . . . Speculations of this description, imperfect as they confessedly are at present, may one day lead to the most important results, and may teach us many truths, respecting the earliest condition of our planet, which the science of astronomy could never have suggested.

* Vindiciæ Geologicæ, pp. 23, 24.

And surely no one ought to consider such enquiries too bold for our limited faculties, needless for our present, or dangerous for our future welfare. No naturalist, desirous of knowing the truth, can be so weak as to fancy that any search into the works of God, or any contemplation of the wonders of His creation, can interfere with the lessons He has taught us in His revealed and written word."*

Before we depart from this, which may be termed the mineral group of evidences for the truth of the Dynamical Theory; and while we allude to the precision with which these evidences point to the line of demarcation between those extensively persistent rocky deposits, occasioned by the general outbreaking and upheaving commotion of the first rotation, and the finely comminuted and more tranquilly deposited earthy and clayey formations of the upper tertiaries; we must not overlook the concurring testimony as to their isolated character, which was alike deduced from their *internal structure,* or *composition,* and from their *situations.* These facts, which are perfectly in accordance with disintegration, occasioned by water agitated by fierce winds, and consequently acting on each locality, without being attended by progressive motion; is wholly inconsistent with the violent rush of water which was occasioned by the protorotation of the earth.† While the local comminution and depositions, which seem so strongly to be evidenced by the newer tertiary rocks; and which have drawn from so many geologists the concurring opinion, that they were formed in lakes and estuaries, at mouths of rivers, and from the detritus of surrounding hills and anterior formations —an opinion more strongly and truthfully expressed by Mr. Phillips than by any of his contemporaries—is satisfactorily corroborative of a system which disowns them as the result of an impetuous onward rush of water, speedily evaporated from the high lands and dry portions; while, on the

* Botany, in Cab. Cyc. pp. 310—314. Part of this quotation has been given already, but such repetitions are almost unavoidable; inasmuch as one passage, from any author, may, and not unfrequently does, afford evidence in favour of several distinct positions, each of which is sought to be established.

† It may be worthy of notice, that in the standard Spanish edition of the Bible, this violent "*agitation*" of the water is particularly mentioned, both in the text and in the notes, more especially in the latter.

other hand, it refers them to the more stationary, though not altogether tranquil subsidence of the waters of the deluge, when "God remembered Noah, and every living thing, and all the cattle that *was* with him in the ark: and God made a wind to pass over the earth, and the waters assuaged; the fountains also of the deep, and the windows of heaven, were stopped, and the rain from heaven was restrained; and the waters returned from off the earth continually: and after the end of the hundred and fifty days the waters were abated."*

* Genesis viii. 1—3.

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXVII.

Erratic block group. The importance of travelled debris in substantiating the Dynamical Theory. Geologically described, and copious evidences given respecting them. The information acquired applied to the point under discussion, and to the assumed condition of the earth, at the period of the origin of the Erratic Block Group, and found to agree most conclusively.

Our attention is now to be directed to the last division of geological phenomena which we require to bring before our readers—a class whose elucidation, by means of this hypothesis, is almost of itself capable of proving the soundness of our views. We allude to the *fragments* of rock, on which Sir Henry de la Beche has conferred the title of the "*Erratic Block Group,*" a designation which will be found to be very appropriate, when the true origin and history of the *debris*, of which it is composed, shall have been investigated by the light of the Dynamical Theory.

A learned geologist, having occasion to allude to some of the boulders of the north of England, said, "that many of them fortunately were land-marks, and boundary stones of parishes, otherwise much of their curious history would have been lost under the hammer of the mason and of the road maker."* While gladly adopting, we would likewise extend this idea, and add, that fortunately, indeed, have they been preserved, from respect to those minor offices which they now fulfil; for

* Professor Phillips, at the British Association, 1836.

they likewise perform the more important duty of pointing out to the world's inhabitants, how this pedestal, on which they are wheeled through space, received its variety of hill and dale from the hands of their common Creator! In short, they are the "land-marks" of the Dynamical Theory, and exhibit, in language which can neither be misinterpreted nor denied, that the earth, when first caused to revolve around its axis, received the form, which, in its greater outlines, it still preserves.

But let us first adduce the geological evidences, and afterwards draw the appropriate inferences. The *thirty-fourth* Theorem has exclusive reference to these interesting fragments, and states—"*That in several parts of Europe and America, immense quantities of travelled debris, gravel, and massive boulders, termed by Sir H. de la Beche* "THE ERRATIC BLOCK GROUP," *are found either resting on, or imbedded in the soil. That the boulders and larger debris, when they have been traced to the nearest fixed group of the same mineralogical character, are generally found to have come from a considerable distance. That those boulders in Britain, Germany, Russia, and North America, whose sites and derivations are ascertained, have been identified with mountain chains existing to the north of where they now lie; whilst those in South America seem, on the contrary, to have originated from localities southward of their present resting places. Finally, the the position of the gravel and smaller detritus appears to have been materially modified by local formations.*"

The evidences on which this important theorem rests, being of a very interesting character, we shall give them at considerable length:—

"There are," says Professor Phillips, "geologists who would gladly expunge the word diluvial from our nomenclature, and instead of appealing to one or several general convulsions for the explanation of some striking fact, are willing to believe that small and local forces, operating through long time, are sufficient for the purpose of geological speculation. In many instances we concede to these writers, that streams wandering in any required direction, over ground indefinitely variable in level, might, in the course of unlimited time, transport detritus in directions not possible during the present or any prior *statical* condition of the earth's surface. But who will

grant these postulates, for the purpose of avoiding the appeal to sudden and energetic disturbances of the relative level of land and water, that has seen the enormous dislocations of the carboniferous system of South Wales and the north of England, the prodigious and extended faults in the south of England chalk; or has imagined to himself the upraising of a chain of mountains like the Alps, or witnessed the enormous conglomerates on their flanks? And if a case can be adduced so circumstanced, that those postulates must be rejected, on good geological evidence, what is to be done but to allow the alternative, namely, the occurrence of great and violent movements of large bodies of water, partial though not general deluges?"

"The erratic blocks," continues Prof. Phillips, "as the larger boulders are called, which have been transported from the Alps, are most remarkable on the eastern face of the Jura, which looks towards the Alps, over the vale of the Arve and the lake of Geneva. On the Jura, 1,500 to 2,000 feet above the lake of Geneva, crowning the hills and filling the valleys and rocky glens, in and around the lake of Geneva and the valley of Arve, as well as along the valleys which descend from the Alps, these blocks abound. It is observed that the blocks abound opposite to the embouchures of these valleys, and that distinct sets of blocks derived from different mountains have followed the lines of the different valleys. The blocks in the valley of the Rhine have come from the Grissons; those by the lake of Zurich and the course of the Limmat were drifted from Glaris; blocks from the source of the Reuss have followed this river; the blocks of the Aar, and the slopes of the neighbouring Jura have come from the range of the Oberland of Berne. From these facts, and the circumstance that the height to which the blocks have ascended the Jura, no doubt can be entertained, that the currents flowed from these mountains in many directions, and followed the line of the present valleys. It appears the most probable view of these phenomena that a general and violent convulsion of the Alps, while they were surrounded by water (whether fresh or salt we cannot decide) caused powerful currents to rush away from the axis of movement, bearing ice rafts loaded with the loosened rocks.

"This explanation appeared satisfactory to Venturi, reasoning on the phenomena of the south side of the Alps; it has been suggested from the case of the blocks on the drainage of the St. Lawrence, and

is proposed as the most probable view of the facts observed concerning the multitude of rock masses which have crossed the Baltic, and dropped in heaps on the plains of Northern Germany, Poland, and Russia, from the Ems and the Weser, to the Dwina and even the Neva. These blocks are grouped in narrow elliptical areas, with the longer axis pointing north and south, or towards the Baltic; they often lie on the surface, especially the larger blocks, hardly ever at great depths. They consist principally of granite, seinite, porphyry, and transition limestones, with characteristic fossils which can be exactly paralleled in the southern parts of Sweden and nowhere else. . . . . . The blocks are more numerous on the Swedish side of the Baltic, nearer their origin, but not larger. Worn and polished surfaces among the primary rocks of Sweden are attributed to the transport of heavy bodies.

"The dispersion of blocks from the Cambrian group of mountains is extremely remarkable; and the example is more valuable to geology than most others of this nature, from the exactness with which the circumstances are ascertained. There are also peculiar relations of the tracks followed by the blocks to the ancient physical features of the country. . . . . . In this passage (that is, of the blocks and other detritus from the Cambrian mountains), three ridges of anciently elevated land, and two deep geologically ancient vales were crossed; yet the water so far respected the elevations of ground now existing, as not to cross the Penine chain at more than one, and that *the lowest point opening directly to the west*, and to avoid the highest part of the oolitic moors. What renders this more curious and complete is the circumstance that one of the valleys crossed (the vale of Eden) 1,000 feet below the origin of the granite, and 1,000 feet below Stainmoor, is a valley caused by dislocation of the carboniferous system *prior to the new red sandstone era*, and the date of the dispersion of the blocks is since the newest tertiaries in the north of England." . . . . .

Somewhat further on, he continues—

"It is evident from all that has been proved, inferred, and admitted on the subject of the *erratic blocks*, that they were derived from particular mountain groups, drifted thence to limited, though considerable distances, along lines which respect the present levels of the country, both as to height and direction. They lie generally at the surface of the superficial marine diluvium, and speak plainly of

great and violent convulsions. Yet it is already certain that they are monuments of merely local, however violent disturbances, not proofs of universal or even very great or general floods."

And finally, on this subject, from Professor Phillips—

"The clay (in the diluvial accumulations of Holderness) in particular, usually of a brown or blue colour, is uncommonly full of pebbles and large boulders (from a hundred-weight to a ton and upwards), of sandstones, limestones, and greenstones, derived from Western Yorkshire; slates, porphyries, and granite from Cumberland; diallage rocks, mica-slate, with garnets, gneiss, &c., and referable either to Scotland or Norway, and many stones of whose origin no satisfactory account can be given.

"The aggregation of the mass is such as utterly to forbid belief that it was heaped together by anything short of a mighty mechanical agency, which in its tempestuous violence permitted none of that distinction of specific gravity, form, or magnitude of the masses to appear in the deposit, which is invariably seen in every case of gradual or intermitting effect of ordinary streams or tides."*

With respect to this group of rocks, M. de la Beche says—

"The origin of the various transported gravels, sands, blocks, and rocks, and other mineral substances scattered over hills, plains, and on the bottoms of valleys, often referred to one epoch, may belong to several. In a word, all the transported matter commonly termed *diluvium*, requires severe and detailed examination. At the present time there would appear to be three principal opinions connected with the subject.

One, supposes the transport to have been effected at one and the same period. Another, that several catastrophes have produced these superficial gravels; while a *third* would seem to refer them to a long continuance of the same intensity of natural forces as that which we now witness. . . . . . These different opinions, though they cannot each be correct in explanation of all the observed facts, may each be so in part, and it were to be wished that the phenomena here arranged under one head solely for convenience, were examined without the controul of a pre-conceived theory." . . . . .

After detailing a great many instances of transported boul-

* Treatise on Geology, pp. 205, 206, 208—210, 215.

ders, blocks, and other mineral detritus, and combatting the opinion of their being produced by atmospheric waste, he goes on to say—

"The probability, therefore, as far as the above facts seem to warrant, is, that a body of water has proceeded from north to south over the British Isles, moving with sufficient velocity to transport fragments of rock from Norway to the Shetland Isles and the eastern coast of England; the course of such a body of water having been modified and obstructed among the valleys, hills, and mountains which it encountered; so that various minor and low currents having been produced, the distribution of the detritus has been in various directions.

"If the supposition of a mass of waters having passed over Britain be founded on probability, the evidences of such a passage or passages should be found in the neighbouring continent of Europe; and the general direction of the transported substances should be the same. Now, this is precisely what we do find. In Sweden and Russia, large blocks of rock occur in great numbers, and no doubt can be entertained that they have been transported southward from the north. . . . . . Proceeding south, the course of the waters seem to have continued in that direction over the low districts of Germany to the Netherlands, depositing large blocks in their passage; these blocks are proved by their mineralogical composition to have been derived from rocks known to exist in the northern regions.

"Such a movement as this over part of Europe would, if the supposition of the mass of waters were correct, be observed in other northern regions, for the waters thrown into agitation would cause waves around the centre of disturbance. In America, therefore, we should expect to find marks of such a deluge, the evidences pointing to a northern origin. Now, in the northern regions of that country we do find marks of an aqueous torrent bearing blocks and other detritus before it, the lines of their transport pointing from the northward, according to Dr. Bigsby, and reminding us of the same appearances observed in Sweden and Germany. The quantity of transported matter covering various large tracts in North America, seems quite equal to that scattered over Northern Europe; and as they both point one way, we can scarcely refuse to admit that the cause of the disturbance or disturbances was towards the north; the undulations of the water having been caused by some violent agitation, perhaps beneath the sea in those regions, for it is by no means

necessary that it should be above its level. . . . . . Solutions of the problem of erratic blocks seem not very practicable at present, and our attempt at general explanations can be considered little else than conjectures, that may appear less or more probable."*

Mr. Ansted corroborates these statements by the following remarks respecting travelled debris:—

"It seems reasonable," says he, "to assume that the first elevation of great masses of land, some part of which now consists of lofty mountain peaks of granite and of igneous rocks, should have been accompanied by local disturbances of the bed of the sea, producing waves capable of transporting large quantities of broken rock, and that by a succession of similar movements these fragments might be conveyed, being more and more pounded and rolled, to a distance of many miles, or even hundreds of miles. Perhaps it may be because the quantity of land elevated in the Arctic circle was lifted up under different circumstances, and in more uniform, dome-shaped, and larger masses, producing more powerful waves; that the fragments broken off from the old rocks of Scandinavia, Lapland, and northern Russia, and the northern parts of our own island (which have all partaken of this movement and its consequences) have been farther transported, and are deposited in more regular, more widely spread, and more characteristic beds of gravel than the Alpine rocks, whose range is, in every respect, more limited. The whole subject of the distribution of gravel is, however, one abounding in difficulties which have as yet been only partially explained. Besides assuming the action of great waves acting for a very short time immediately after an earthquake shock, and propelling a mass of broken rock with irresistible power at a rapid rate for a short distance, some geologists have called in the aid of marine currents. The action of the waves on an ordinary coast-line is also itself sufficient to account for many even of the more striking phenomena. . . . Whatever the cause or causes may have been, the distribution of numerous blocks of stone, sometimes rounded, but more frequently angular, and of every size and shape, and the removal of these to various distances from the parent rock, are facts distinctly made out. Such blocks, also, are not confined to Northern Europe, but are met with both in North and South America, and in other parts of the world. It is, however, certain that true gravel, with rolled blocks

* Manual, pp. 164, 171, 173, 177.

of stone, is not universally distributed ; and the effects thus produced have been as partial as they were frequent, the result being quite different. It thus happens that, while in most cases common gravel, or transported and erratic blocks and boulders have been deposited, we find elsewhere only great masses of mud and clay, mixed with stones, sand, or any other material drifted into recesses, and left there by the iceberg or the retiring wave."*

Mr. Lyell, when treating of this division of geological research, says—

"Between the superficial covering of vegetable mould and the subjacent rock, there usually intervenes in every district a deposit of loose gravel, sand, and mud, to which the name of *alluvium* has been applied. . . . . .

"A partial covering of such alluvium is found alike in all climates, from the equatorial to the polar regions, but in the higher latitudes of Europe and North America it assumes a distinct character, being very frequently devoid of stratification, and containing large fragments of rock, some angular, and others rounded, which have been transported to great distances from their parent mountains. When it presents itself in this form it has been called 'diluvium,' 'drift,' or the 'boulder formation,' and its probable connexion with the agency of floating ice and glaciers will be treated of more particularly in the sequel.

". . . . . Mention," he continues, "was made in a previous chapter of an ancient alluvium in the North of Europe, called the "boulder formation." . . . . . I shall first describe briefly that portion of it which extends from Finland and the Scandinavian mountains to the north of Russia, and the low countries bordering the Baltic, and which has been traced southwards as far as the eastern coast of England.

"This formation consists of mica, sand, and clay, sometimes stratified, but often wholly devoid of stratification, for a depth of more than one hundred feet. To this unstratified form of the deposit, the name of *till* has been applied in Scotland. It generally contains numerous fragments of rocks, some angular, and others rounded, which have been derived from formations of all ages, both fossiliferous, volcanic, and hypogene, and which have often been brought from great distances. Some of the travelled blocks are of

* Ancient World, pp. 323—326.

enormous size, several feet or yards in diameter; their average dimensions increasing as we advance northwards. . . . . . Although a large proportion of the boulder deposit is made up of fragments brought from a distance, and which have sometimes travelled many hundred miles, the bulk of the mass in each locality consists of the ruins of subjacent or neighbouring rocks; so that it is red in a region of red sandstone, white in a chalk country, and grey or black in a district of coal or coal shale.

"That the erratics of Northern Europe have been carried southward, cannot be doubted; those of granite, for example, scattered over large districts of Russia and Poland, agree precisely in character with rocks of the mountains of Lapland and Finland; while the masses of gneiss, syenite, porphyry, and trap, strewed over the low sandy countries of Pomerania, Holstein, and Denmark are identical in mineral character with the mountains of Norway and Sweden. It is found to be a general rule in Russia, that the smaller blocks are carried to greater distances from the point of their departure than the larger; the distance being sometimes 800 and even 1,000 miles from the nearest rocks from which they were broken off; the direction having been from north-west to south-east, or from the Scandinavian mountains over the seas and low lands to the south-east. . . . . . Again—" Now, some or all of the marks enumerated, the moraines, erratics, polished surfaces, striæ, caldrons, and perched rocks, are observed in the Alps at great heights above the present glaciers, and far below their actual extremities; also in the great valley of Switzerland, 50 miles broad; and almost everywhere on the Jura, a chain which lies to the north of this valley. The average height of the Jura is about one-third that of the Alps, and is now entirely destitute of glaciers, yet it presents almost everywhere similar *moraines*, and the same polished and grooved surfaces, and water-worn cavities. The erratics, moreover, which cover it, present a phenomenon which has astonished and perplexed the geologist for more than half a century. No conclusion can be more incontestible than that these angular blocks of granite, gneiss, and other crystalline formations, came from the Alps, and that they have been brought from a distance of 50 miles and upwards across one of the widest and deepest valleys of the world, so that they are now lodged on the hills and valleys of a chain, composed of limestone and other formations, altogether distinct from those of the Alps.

"Their great size and angularity, after a journey of so many leagues, has justly excited wonder; for hundreds of them are as

large as cottages; and one in particular, celebrated under the name of Pierre à Bot, rests on the side of a hill, about 900 feet above the lake of Neufchatel, and is no less than 40 feet in diameter. . . . . . But in Scotland the submergence of the lower country, and the co-operation of floating ice, seems more indispensable than in the case of Switzerland; for the points from which the Grampian boulders have been conveyed are much lower, and those to which they have been carried equally remote. One fragment of the mica-schist, weighing from 8 to 10 tons, has been pointed out by Mr. Mac Laren as occurring at the height of 1,100 feet above the sea on the Pentland Hills; the nearest mountain composed of this formation being 50 miles distant.

"It was stated that the boulder deposit of Russia reposed on strata containing recent marine shells, but the till in Scotland rests immediately on the older rocks, and is covered by stratified sand and clay, which usually contain no fossils. At certain points, however, near the coast, as for example, in the estuaries of the Tay and Clyde, marine shells have been discovered in strata overlying the till. They occur on the Clyde at the height of 70 feet; but the deposit, of which they form an integral part, rises in the same country to an elevation of several hundred feet. Although between 80 and 90 per cent. are of recent species, the remainder are unknown; and even many which are recent, now inhabit more northern seas, where we may hereafter hope to find living representatives of some of the unknown fossils. From the arctic character of this fauna, which resembles that of Quebec, before described, we may infer that these strata and the subjacent till are of higher antiquity than some parts of the boulder deposit of northern Europe."*

Mr. Miller, when describing so inimitably a few of the first of those days of labour, which eventually led to such distinction, thus touches on "the boulder formation" with which we are now engaged—

"The evening furnished me," says he, "with still further cause of wonder. We raised another block in a different part of the quarry, and found that the area of a circular depression in the stratum below was broken and flawed in every direction, as if it had been the bottom of a pool recently dried up, which had shrunk and split

* Lyell's Elements, vol. i. pp. 164, 165, 222—224, 248, 255.

in the hardening. Several large stones came rolling down from the diluvium in the course of the afternoon. They were of different qualities from the sandstone below and from one another; and, what was more wonderful still, they were all rounded and water-worn, as if they had been tossed about in the sea, or the bed of a river, for hundreds of years. There could not, surely, be a more conclusive proof that the bank which had enclosed them so long could not have been created on the rock on which it rested. No workman ever manufactures a half-worn article, and the stones were all half worn! And if not the bank, why then the sandstone underneath? I was lost in conjecture, and found I had food enough for thought that evening, without once thinking of the unhappiness of a life of labour. The immense masses of diluvium which we had to clear away rendered the working of the quarry laborious and expensive, and all the party quitted it in a few days to make trial of another that seemed to promise better. . . . . . I soon found I was to be no loser by the change. Not the united labours of a thousand men for more than a thousand years could have furnished a better section of the geology of the district than this range of cliffs. It may be regarded as a sort of chance dissection on the earth's crust. We see in one place the primary rock, with its veins of granite and quartz, its dizzy precipices of gneiss, and its huge masses of hornblende; we find the secondary rock in another, with its beds of sandstone and shale, its spars, its clays, and its nodular limestones.

"We discover the still little-known but highly interesting fossils of the old red sandstone in one deposition; we find the beautifully preserved shells and lignites of the lias in another. There are the remains of two several creations at once before us. The shore, too, is heaped with rolled fragments of almost every variety of rock, basalts, ironstones, hyperstones, porphyries, bituminous shales, and micaceous schists. In short, the young geologist, had he all Europe before him, could hardly choose for himself a better field."*

Whilst these evidences are vividly before the mind, if we recur, in the first instance, to what has been said of the disintegrating influence exercised by the protruded rocks upon the strata through which they burst, when the earth was first caused to revolve around its axis; afterwards take into consideration the infinite number of fragments, of all dimensions,

* Old Red Sandstone, pp. 40, 41.

which must have been spread abroad from each elevated chain, as it assumed its relative height and present form; and then direct the attention to the rush of water which, at the same time, was sweeping with inconceivable rapidity from the poles towards the equator, acquiring a westerly direction as it advanced; and take into account its capacity as a carrier of debris, we shall no longer be at a loss to account for the distance travelled over, or for the relative direction in which so many of the boulders are found, with respect to the rocks from which they appear to have been torn. For, on viewing the subject, under these considerations, with reference to what was then taking place, the following considerations present themselves almost spontaneously:—

That the fragments would be massive and numerous in proportion to the height of the mountain ranges from whence they emanated, or what is precisely the same, in proportion to the violence with which the protruded rocks perforated the the superincumbent strata. That these effects would be modified considerably by the nature of both the perforating and the perforated substances. That they would be removed to distances in direct proportion to the velocity of the conducting fluid, and inversely as their respective masses.

That the evidence of the distance over which they may have travelled, such as the rounding of their angles and all other asperities—the usual symptoms of attrition on mineral matter—would be the greater the nearer they are found to the equatorial regions, and the more moderate their size. That the effects of local formations in determining their present relative sites would be rather complexly manifested, from the influential circumstance, that, as the land was simultaneously assuming its present form, the effects of its undulations, as a modifying cause, would be exercised and become apparent by the results, in direct proportion to the distance between the sites of the fragments and their parent rock; or, in other words, in proportion to the time they were in motion, in consequence of the earth having been all the while approaching nearer and nearer to its perfect form of equilibrium when in rotation.

Assuming these, therefore, to be the conditions of the problem, it appears to us, that as the specific gravity of the

boulders, relatively to the fluid, was the same *everywhere;* while the velocity of the latter would be in proportion to the latitude, we should find, as the first and most immediate result, that the distances between the actual positions of the boulders and the place from whence they came will be greatest in highest latitudes; and as the current, in flowing towards the equator, acquired a westerly direction, by a composition of these two forces; the boulders of the northern hemisphere should be found generally to be in situations bearing south-westerly from the places of their origin; the westerly deviation being more remarkable the nearer to the equator, a conclusion, agreeing perfectly with what is shown by the foregoing evidences, in a clear and intelligible manner, to be the case.

It must be understood to follow, as strict deductions from what has been here advanced, that in instances where detached masses are enormously great, and have been transported to only short distances from their parent rocks, they would then, in a corresponding manner, be but slightly diverted from their equatorial course, whether they had their origin in the northern or in the southern hemisphere.

And, that as the earth, during the same brief period, was assuming its present exterior form—that of equilibrium under rotation—there would occur numberless instances, where immense fragmental masses (and the more massive the more likely to happen), after having been swept over considerable intermediate spaces, may have been arrested by the upheaving shoulders of some mighty mountain chain, as it interposed itself like a barrier to their onward course; may have been carried up to greater elevations along with it, whilst the surface over which they had previously and but recently travelled, may have simultaneously sunk down, as a co-effect of the elevation of the intercepting range, and have become a broad and wide valley, thereby facilitating the onward equatorial course of the rushing waters, which thus left those great land marks of their path behind them.

We feel persuaded, that where circumstances are favourable for the examination and the identification of blocks and boulders, these results will be found to have taken place, and

thereby will furnish the most undeniable evidence of the correctness of these conclusions.

The influence exercised, by the *form* of the earth, in modifying the relative sites of these boulders, when their other prognostics, such as the distance of their route, &c., are taken into account, together with a candid and attentive application of the whole phenomena, will be found to yield the most satisfactory results, and the most perfect elucidation of those geological manifestations which abound; and to afford one of the most convincing tests of the soundness of the Dynamical Theory. For we feel convinced, that those influential conditions, and those conditions alone, will resolve the enigma, which hitherto has baffled all attempts to explain it, namely—the manifest indifference shown, during their projectile progress, by several immense boulders, located among the Alps, to the enormous mountains which at present intervene between them and the places of their origin; giving rise to innumerable hypothetical conclusions, and to the necessity of calling in the aid of wonder-working *debacles* to account for their translation; while, at the same time, the comparatively smaller and more distant travelled ones of the North of England present the contradictory evidence of having paid every respect to the sinuosities of the land over which they voyaged, having "been drifted in certain lines, so as to show that the causes, whatever they were, which produced the phenomena, were not capable of overcoming, except in a limited degree, the natural obstacles of the country."* In the former case, the boulders must have been removed simultaneously with the rising of the land, and during the time that the waters were in violent motion; whereas, the latter having continued their route for a greater length of time, were influenced, at every step, by two conjoint retarding causes, the more perfect formation of the land, and the decreasing rapidity of the transporting medium, as it approached its static form and condition of equilibrium.

Indeed, so convinced are we of the soundness of these conclusions, that we venture to stake the validity of this part of

* Professor Phillips, before the British Association at Bristol, Sept. 1836.

the Dynamical Theory on the assertion, that whenever the travelled boulders of the *southern* hemisphere are examined by impartial geologists, they will be found to occupy corresponding positions, with respect to the rocky formations whence they, too, have proceeded. That is, it will be discovered, *in general*, that they have been removed in a direction towards the *north-west*, with all the corresponding inflexions, which similar local circumstances are found to have produced on those of the northern hemisphere.*

In addition to those observations on the evidences afforded by the "Erratic Block Group," we take occasion to remark, that there is scarcely any geological data more strongly corroborative of the Dynamical Theory, than the widely spread deposits of rolled pebbles which not unfrequently abound. When the unstratified rocks burst through the superincumbent strata, the scattering of innumerable fragments of all descriptions, shapes, and sizes must have been the immediate consequence; but *not one of them could have been round when torn off the parent rock:* so certainly as the one rock perforated and passed another, so certainly would the detached fragments be angular, ragged, and pointed. On the other hand, when this convulsion took place, had the whole not been enveloped in much water, a hypothetical combination which might be supposed to have occurred if *heat* or *fire* had caused the catastrophe, then the fragments alluded to would have remained almost as angular and as ragged and pointed as when they were detached. Had the displacement, and its natural consequences, occurred in the midst of water, *without any peculiar impetus*, such as a rush from the poles towards the equator, to complete the

* The assertion contained in this passage, which was written in 1836, has been fully verified intermediately by the investigations of those geologists who have since then had opportunities of visiting the southern regions of the globe, more especially in Chili, Bolivia, and Peru, where boulders and massive fragments, resulting from this great day's work, and general commotion over all the earth's surface, are found strewed everywhere around the flanks and amongst the hollows of the huge and far stretching Cordillera, themselves one of the most striking monuments of protorotation long posterior to the deposition and induration of our sphere's concentric stratified envelope, the work of protracted darkness and non-rotation. For one example, see Lyell's Elements, vol. i. p. 251.

figure or static condition of rotation, it is not at all probable, that the stones and fragments, to which we refer, would or could have assumed the perfect appearance of much attrition and of distant travel which those beds of pebbles do. They evidence by their perfect sphericity, in many instances, when coupled with the solidity of their material, that it was no *common* flood, no *short* space travelled over, nor no *moderate* speed which conferred on them their smoothly rounded forms, and which have acquired for them the designation of "*travelled* fragments."

It is equally as satisfactory to reflect, on taking another view of the case, that without their presence in the precise conditions in which they are found, all our assumptions would have been incomplete, and liable hereafter to have been considered erroneous. And thus, the rolled pebbles afford both positive and negative proof in favour of the cosmography which we inculcate.

It is with peculiar satisfaction, mingled with thankfulness, that we are thus enabled to close the geological evidences for the truth of the *Dynamical Theory* with a class of phenomena so universal and so admirably adapted as are the components of the "erratic block group," both by their character and their durability, to point out the form which the earth assumed on being caused to revolve around its axis. No evidences could possibly have been more appropriate than these "boulders," tangible as they are to the senses, and everywhere to be found. Most heartily ought we to thank the great Creator of all, for having permitted, in His infinite wisdom, that these effects should have proceeded from natural causes, in order, that along with the other designs, which they were intended to fulfil, they should afford the most undeniable evidence, *that when they were torn asunder from their parent rocks, and strewed over and imbedded in the surface of the surrounding soil, the globe was in the act of receiving from His almighty hand, "who weighed out its hills in His balance," the identical inflexions of surface which, to the present moment, it retains.*

SECTION VI.

GEOLOGICAL PHENOMENA RESULTING FROM THE EARTH'S PROTOROTATION.

CHAPTER XXVIII.

Brief recapitulation of the principal subjects of this Section. Uranographical effects of the transformation of the earth, from a non-rotating sphere to a spheroid of rotation. Series of evidences. Precession of the equinoxes astronomically explained, and its bearing on the question pointed out. Geologically confirmed. Chronological data to show at what period the longer axis of the solar ellipse coincided with the equinoxes. Conclusion drawn from a combination of these evidences, that the precession of the equinoxes commenced with, and is dependent for its existence on the earth's protorotation; and, that the commencement of the two was coeval, and their periods have had the same duration. A combination of these established positions, with the fact of "matter never engendering motion in itself," employed to show, that the earth's motions must have originated from the Creator, and that the Creator is God.

On reviewing the leading points of this protracted section it will be perceived, first of all, that evidences of a *mechanical* character have been adduced to prove, that the earth, which, during the period of darkness circulated around the unilluminated sun without diurnal motion, was, by the formation of the light, and its division from the darkness, caused to revolve around its axis. Having dwelt sufficiently on that particular point we proceeded to enquire, in continuation, what were likely, *theoretically*, to have been the results of this new motion upon the general outlines of the globe. After these were defined, as nearly as possible, we entered into a minute and lengthened investigation, which concluded by determining, satisfactorily, that not only all *geological* phenomena, but

likewise the *greater general elevation* of *lands* within the equatorial regions, and the formation of *continental ridges* and *oceanic hollows* accorded with these theoretical conclusions.

In concluding the geological enquiries, we attended both to the *external* evidences afforded by the action of one rock upon another, and also to the *internal* evidences, arising from the mineralogical structure of the primary and older secondary rocks, supposing them to have been moved from where they were considered, in our previous chapters, to have been formed. We likewise included, in these investigations, the mineral veins, dykes, and fissures, and the metallic lodes, and made manifest that *they*, too, could be satisfactorily accounted for by the same theory. Going on, afterwards, to the sedimentary rocks, which owe their origin to the deposition of *debris*, spread abroad by the elevation of mountain chains, it was shown, that with the exception of some of the more recent of the tertiary, whose origin we hinted at in passing, they, likewise, correspond in geological developments with what might, *a priori*, have been expected from the first rotation of the earth around its axis, after induration had taken place at the period alluded to. And we concluded the whole with a brief description of the "erratic block group," which was also found to be susceptible of easy elucidation, by the facts and arguments brought to bear upon it.

Under these concurring and favourable circumstances, looking upon the *geological* and *mineralogical* evidences as being uninterruptedly linked together from first to last; and feeling assured that the proofs in favour of the Dynamical Theory are persistently conclusive; we now consider ourselves authorised to conclude, as a final deduction from the whole, *that the first revolution of the earth around its axis took place* AFTER *the formation of those materials which now constitute the independent coal measures, and immediately* BEFORE *the deposition of the new red sandstone, the oolitic, and the cretaceous groups:* from which conclusion three important deductions necessarily follow:—

1. That the period during which the earth revolved around the sun *without rotatory motion*, extended from the instant of its being translated in space at "the beginning," from the first

symptom of stratification until the entire deposition of the material which now constitutes the coal measures.

2. That as the protuberance of its equatorial regions arises from its *diurnal* rotation, and this owes its origin to the formation of the light, and its division from the darkness, its excess of equatorial diameter *can have existed only since the date recorded in Scripture as being that of the formation of the light.*

And 3. As a change of form would produce a corresponding effect on the *astronomical* relations of our sphere, this would undoubtedly be perceptible to astronomers by their accurate investigations, which would respond, in fact, to the reverberation which took place from the allied but distant bodies of our system; and should leave upon their records, corresponding evidences of a change in the earth's uranographical phenomena, indicative of that alteration of form which geology leads us to consider it underwent; while the exact nature of those deductions should assign the precise period, or nearly so, when this perturbation was first perceptible in the motions of our planet. That, should such be the case, all our views would be corroborated by the testimony of a science dedicated to the investigation of laws which govern regions of space far beyond the sphere we tread upon; and we would enjoy the satisfaction of beholding these sciences mutually shedding their lights on each other, and unitedly conspiring to the advancement and to the establishment of the TRUTH.

In order to discover whether such, in reality, is the case, let us attend to what is stated in the *seventh* Theorem, "*That owing to a secular motion in the position of the major axis of the solar ellipse, arising from a direct motion of the perigee and the retrogradation of the node of the earth's equator on the ecliptic (called the precession of the equinoxes), which conjointly accomplish an entire revolution in 20,984 years, a corresponding, gradual, but entire change is going on in the relative positions of the major axis and the line of the equinoxes; which, about 4,000 years before the Christian era, coincided with each other.*

"*And that this secular change is the necessary consequence of the rotation of the earth and the disturbing action of the*

sun and moon on the redundant matter accumulated about the earth's equator."

These results being deduced from principles in astronomy, not very apparent at first sight, and depending on two motions entirely distinct in their nature and origin, they will require to be partially analyzed, and laid open to the view, by explanations drawn from the same sources which furnished the materials for the theorem. In doing this, we shall commence with the "direct motion of the perigee," more with the design of eliminating it from our argument, than from any immediate tendency it has to aid our convictions; the phenomena which principally interests us in our general inquiry being the *retrogradation of the node of the earth's equator on the ecliptic.*

The following extract proves the effect produced on our satellite in consequence of the redundant matter accumulated in the equatorial regions, and the reciprocal light which this sheds upon the external form and the internal structure of the earth:—

"The moon is so near," says Mrs. Somerville, "that the excess of matter at the earth's equator occasions periodic variations in her longitude, and also that remarkable inequality in her latitude, already mentioned as a nutation in the lunar orbit, which diminishes its inclination to the ecliptic, when the moon's ascending node coincides with the equinox of spring, and augments it when that node coincides with the equinox of autumn.

"As the cause must be proportional to the effect, a comparison of these inequalities, computed from theory with the same given by observation, shows that the compression of the terrestrial spheroid, or the ratio of the difference between the polar and the equatorial diameters to the diameter of the equator, is $\frac{1}{305.05}$. It is proved analytically, that if a fluid mass of homogeneous matter, whose particles attract each other inversely as the square of the distance, were to revolve about an axis as the earth does, it would assume the form of a spheroid, whose compression is $\frac{1}{230}$. Since that is not the case, the earth cannot be homogeneous, but must decrease in density from its centre to its circumference. Thus, the moon's eclipses show the earth to be round; and her inequalities not only determine the form, but even the internal structure of our planet; results of analyses which could not have been anticipated." And again—"The larger

planets rotate in shorter periods than the smaller planets and the earth. Their compression is consequently greater, and the action of the sun and their satellites, occasions a nutation in their axes, and a precession of their equinoxes, similar to that which obtains in the terrestrial spheroid, from the attraction of the sun and moon on the prominent matter at the equator."*

Having thus become briefly acquainted with the nature of the slow secular perturbation alluded to, and which but slightly affects us, we shall next proceed to enquire into that of "*the retrogradation of the node of the earth's equator on the ecliptic;*" and beg that particular attention may be paid to the important evidences about to be brought forward:—

"The problem," says Professor Playfair, "which Newton had thus concluded, enabled him to resolve one of still greater difficulty. The *precession*, that is, the retrogradation of the equinoctial points, had been long known to astronomers; its rate had been measured by a comparison of ancient and modern observations, and found to amount to nearly 50″ annually, so as to complete an entire revolution of the heavens in 25,920 years. Nothing seemed more difficult to explain than this phenomenon, and no idea of assigning a physical or mechanical cause for it had yet occurred, I believe, to the boldest and most theoretical astronomers. The honour of assigning the true cause was reserved for the most cautious of philosophers. He was directed to this by a certain analogy observed between the precession of the equinoxes and the retrogradation of the moon's nodes, a phenomenon to which his calculus had been already successfully applied. The spheroidal shell or ring of matter which surrounds the earth, as we have just seen, in the direction of the equator, being one-half above the plane of the ecliptic and the other half below, is subjected to the action of the solar force, the tendency of which is to make this ring turn on the line of its intersection with the ecliptic, so as ultimately to coincide with the plane of that circle. This, accordingly, would have happened long since, if the earth had not revolved on its axis. The effect of the rotation of the spheroidal ring from west to east, at the same time that it is drawn down toward the plane of the ecliptic, is to preserve the inclination of these two planes unchanged, but to make their intersection move in a

* Connexion of the Sciences, pp. 48, et seq.

direction opposite to that of the diurnal rotation, that is from east to west, or contrary to the order of the signs of the Zodiac."*

In another part of his works, when reviewing the *Mechanique Celeste* of M. La Place, he says—

"With the questions of the figure of the earth, and the flux and reflux of the sea, that of the precession of the equinoxes is closely connected; and La Place has devoted his fifth book to the consideration of it. . . . . . Newton was the first who turned his thoughts to the physical cause of this appearance; and it required all the sagacity and penetration of that great man to discover this cause in the principle of universal gravitation. The effect of the forces of the sun and moon on that excess of matter which surrounds the earth at the equator, must, as he has proved, produce a slow angular motion in the plane of the latter, and in a direction contrary to that of the earth's rotation. . . . . .

"That excellent mathematician D'Alembert, gave a solution of this problem that has never been surpassed for accuracy and depth of reasoning, though it may have been for simplicity and shortness. He employed the principle, already ascribed to him, of the equilibrium among the forces destroyed when any change of motion is produced; and it was by means of the equations which this proposition furnished, that he was enabled to proceed without the introduction of hypothesis. . . . . .

"La Place has gone over the same ground, more that he might give unity and completeness to his work, than that he could expect to add much to the solution of D'Alembert. As he has proceeded in a more general manner than the latter, he has obtained some conclusions not included in this solution. He has shown, that the phenomena of the precession and nutation must be the same in the actual state of our terraqueous spheroid, as if the whole was a solid mass, and that is true, whatever be the irregularity of the depth of the sea. He shows also, that currents in the sea, rivers, trade winds, even earthquakes, can have no effect in altering the earth's rotation on its axis. The conclusions with regard to the constitution of the earth, that are found to agree with the actual quantity of the precession of the equinoxes are, that the density of the earth increases from the circumference towards the centre; that it has the form of

* Playfair's Works, vol. ii. pp. 411, 412.

an ellipsoid of revolution; and, that the compression of this spheroid at the poles is between the limits of $\frac{1}{304}$ and $\frac{1}{378}$ part of the radius of the equator."*

"It has been shown," says Mrs. Somerville, in a passage to which we have already had occasion to refer, "that the axis of rotation is invariable on the surface of the earth; and observation as well as theory prove, that were it not for the action of the sun and moon on the matter at the equator, it would remain exactly parallel to itself in every point of its orbit. The attraction of an external body not only draws the spheroid towards it, but, as the force varies inversely as the square of the distance, it gives it a motion about its centre of gravity, unless when the attracting body is situate in the prolongation of one of the axes of the spheroid. The plane of the equator is inclined to the plane of the ecliptic at an angle of 23° 27.38″ 81, and the inclination of the lunar orbit to the same, is 5° 8.47″ 9. Consequently, from the oblate figure of the earth, the sun and moon acting obliquely and unequally on the different parts of the terrestrial spheroid, urge the plane of the equator from its direction, and force it to move from east to west, so that the equinoctial points have a slow retrograde motion on the plane of the ecliptic of 50″ 10 annually. The direct tendency of this action is to make the planes of the equator and ecliptic coincide, but it is balanced by the tendency of the earth to return to stable rotation about the polar diameter, which is one of its principal axes of rotation. Therefore the inclination of the two planes remains constant, as a top spinning preserves the same inclination to the plane of the horizon. Were the earth spherical this effect would not be produced, and the equinoxes would always correspond with the same points of the ecliptic, at least as far as this kind of motion is concerned; but another and totally different cause which operates on this motion has already been mentioned.

"The action of the planets on one another, and on the sun, occasions a very slow variation in the position of the plane of the ecliptic, which affects its inclination to the plane of the equator, and gives the equinoctial points a slow but direct motion on the ecliptic of 0″ 31. annually, which is entirely independent of the figure of the earth, and would be the same if it were a sphere. Thus the sun and moon, by moving the plane of the equator, cause the equinoctial points to retrograde on the ecliptic; and the planets, by moving the

* Playfair's Works, vol. iv. pp. 305—307.

plane of the ecliptic, give them a direct motion, though much less than the former. Consequently, the difference of the two is the mean precession, which is proved, both by theory and observation, to be about 50″ 10 annually. . . . . .

"Moving at this rate annually, the equinoctial points will accomplish a revolution in 25,868 years." . . . . .

And in conclusion from this instructive writer—

"The mean annual precession is subject to a secular variation; for, although the change in the plane of the ecliptic in which the orbit of the sun lies, be independent of the form of the earth, yet by bringing the sun, moon, and earth into different relative positions, from age to age, it alters the direct action of the two first on the prominent matter at the equator; on this account the motion of the equinox is greater by 0″.455 now than it was in the time of Hipparchus. Consequently, the actual length of the tropical year is about 4″.21 shorter than it was at that time. The utmost change that it can experience from the cause amounts to 43 seconds. Such is the secular motion of the equinoxes. But it is sometimes increased and sometimes diminished by periodic variations, whose periods depend upon the relative positions of the sun and moon with regard to the earth, and which are occasioned by the direct action of these bodies on the equator."*

Sir John Herschel thus explains this astronomical arcana—

"The determination of the vernal equinox is a point of great importance in practical astronomy, as it is the origin or Zero point of right ascension. Now, when this process is repeated at considerably distant intervals of time, a very remarkable phenomenon is observed, namely, that the equinox does not preserve a constant place among the stars, but shifts its position, travelling continually and regularly, although with extreme slowness, *backwards*, along the ecliptic, in a direction from east to west, or the *contrary* to that in which the sun appears to move in that circle. . . . . . The amount of this motion by which the equinox *retrogrades* on the ecliptic, is 0° 0′ 50″.10 *per annum*, an extremely minute quantity, but which, by its continual accumulation from year to year, at last makes itself very palpable.

* Connexion of the Sciences, pp. 91—93.

. . . . . Since the formation of the earliest catalogue of stars on record, the place of the equinox has retrograded already about 30°. The period in which it performs a complete tour of the ecliptic is 25,868 years." . . . . .

In continuation, after describing the immediate uranographical effects of the precession of the equinoxes, in giving rise to a uniform increase of longitude to all the heavenly bodies, and the interesting results which this, in turn, occasions, he goes on to say—

"These two phenomena, namely—*precession* and *nutation*, it is true, belong, theoretically speaking, to one and the same general head, and are intimately connected together, forming part of a great and complicated chain of consequences flowing from the earth's rotation on its axis: but it will be of advantage to consider them separately.

"It is found, then, that in virtue of the uniform part of the motion of the pole, it describes a circle in the heavens around the pole of the ecliptic as a centre, keeping constantly at the same distance of 23° 28′.0 from it, in a direction from east to west, with a velocity that the annual angle described by it, in this its imaginary orbit, is 50″.10; so that the whole circle will be described by it in the above-men- cycle of 25,868 years. . . . . . This motion gives rise to the retrograde motion of the equinoxes.

"The pole is nothing more than the vanishing point of the earth's axis. As this point, then, has such a motion as described, it necessarily follows, that the earth's *axis* must have a conical motion. We may form the best idea of such a motion by noticing a child's peg-top, when it spins not upright, or that amusing toy the tee-to-tum, which when delicately executed, and nicely balanced, becomes an elegant philosophical instrument, and exhibits in the most beautiful manner, the whole phenomenon, in a way calculated to give at once a clear conception of it as a fact, and a considerable insight into its physical cause as a dynamical effect. . . . . .

"It will be shown in a subsequent chapter that *precession* and *nutation* are necessary consequences of the rotation of the earth, combined with its elliptical figure, and the unequal attraction of the sun and moon on its polar and equatorial regions."

And, in conclusion from the same work, on this recondite subject—

"The precession of the equinoxes, as we have shown, consists in

a continual retrogradation of the node of the earth's equator on the ecliptic, and is, therefore, obviously an effect so far analogous to the general phenomenon of the retrogradation of the nodes of the orbits on each other.

"The immense distance of the planets, however, compared with the size of the earth, and the smallness of their masses compared to that of the sun, puts their action out of the question in the enquiry of its cause, and we must, therefore, look to the massive though distant sun, and to our near though minute neighbour the moon, for its explanation. This will, accordingly, be found in their disturbing action on the redundant matter accumulated on the equator of the earth, by which its figure is rendered spheroidal, combined with the earth's rotation on its axis. It is to the sagacity of Newton that we owe the discovery of this singular mode of action."*

Before we can draw any conclusion, from these very lucid and concurring evidences, which will be thoroughly convincing, we must endeavour to establish the era when the longer axis of the solar ellipse coincided with the equinoxes. This may be considered accomplished by the following quotations, although there is a difference in the particular coincident equinox assigned by some of the writers.

We shall commence with the following passage from the writings of Mr. Lyell, to whom we have been already so much indebted for enlightening our path amid the mazes of geology, as being the best evidence on this particular point, which is derivable from *that source* of information:—

"That portion of the post-pliocene group," says he, "which belongs to the human epoch, sometimes called *recent*, forms a very insignificant feature in the geological structure of the earth's crust.

* Astronomy, in Cab. Cyc. American edition, pp. 161—166, 309. We take occasion to recommend such of our readers as have the opportunity, to peruse attentively the whole of Sir John Herschel's luminous exposition of this intricate astronomical phenomenon, which unfortunately is too long to be given here, and cannot be abridged, assured that while they derive pleasure and information by so doing, they will be more than ever convinced that precession and nutation are intimately connected with the *redundant matter accumulated round the equator*, or the *earth's equatorial protuberance*. Indeed, Sir John shows by a note, that a SPHERE would be perfectly indifferent to these retrograding influences.—AUTHOR.

I have shown, however, in another work, where the recent changes of the earth, illustrative of geology are described at length, that the deposits accumulated at the bottoms of lakes and seas within the last 4,000 or 5,000 years, can neither be insignificant in volume or extent.

"They lie hidden, for the most part, from our sight; but we have opportunities of examining them at certain points, where newly gained land in the deltas of rivers has been cut through during floods, or where coral reefs are growing rapidly, or where the bed of a sea or lake has been heaved up by subterranean movements and laid dry. Their age may be recognized either by our finding in them the bones of man in a fossil state, that is to say, imbedded in them by natural causes, or by their containing articles fabricated by the hands of man.

"Thus at Puzzuoli, near Naples, marine strata are seen containing fragments of sculpture, pottery, and the remains of buildings, together with innumerable shells, retaining in part their colour, and of the same species as those now inhabiting the Bay of Baiæ. The uppermost of these beds is about 20 feet above the level of the sea. Their emergence can be proved to have taken place since the beginning of the sixteenth century.

"Now here, as in almost every instance, where any alterations of level have been going on in historical periods, it is found that rocks containing shells, all, or nearly all of which, still inhabit the neighbouring sea, may be traced for some distance into the interior, and often to a considerable elevation above the level of the sea. Thus, in the country round Naples, the post-pliocene strata, consisting of clay and horizontal beds of volcanic tuff, rise at certain points to the height of 1,500 feet. Although the marine shells are exclusively of living species, they are not accompanied like those on the coast at Puzzuoli, by any traces of man or his works. Had any such been discovered, it would have afforded to the antiquary and geologist matter of great surprise, since it would have shown that man was an inhabitant of that part of the globe, while the materials composing the present hills and plains of Compania were still in the progress of deposition at the bottom of the sea; whereas, we know that for nearly 3,000 years, or from the times of the earliest Greek colonists, no revolution in the physical geography of that part of Italy has occurred."*

* Elements, vol. i. pp. 214—216.

Dr. Ure observes—

"The date of the earth's creation, according to the chronology of the Hebrew Bible, was 4,004 years before the birth of Christ. Astronomy shows that the great axis or longest diameter of the elliptic orbit, in which our earth revolves round the sun, as placed in one of the foci, coincided at that epoch with the line of the equinoxes. Hence, then, at the instant of the autumnal equinox, the sun was nearest the earth or in perigee, and of the vernal equinox he was in apogee; and therefore his elliptic orbit and time of revolution were each evenly divided between the seasons."*

"Some remarkable astronomical eras," says Mrs. Somerville, "are determined by the position of the major axis of the solar ellipse, which depends upon the direct motion of the perigee, and the precession of the equinoxes conjointly, the annual motion of the one being 11″ 8′; and that of the other 50″ 1′. Hence the axis, moving at the rate of 61″ 9′, annually, accomplishes a tropical revolution in 20,984 years. It coincided with the line of the equinoxes 4,000 or 4,089 years before the Christian era, much about the time chronologists assign for the creation of man. In 6,483 the major axis will again coincide with the line of the equinoxes; but then the solar perigee will coincide with the equinox of autumn, whereas at the creation of man it coincided with the vernal equinox.†

"The variation in the position of the solar ellipse occasions corresponding changes in the length of the seasons. In its present position, spring is shorter than summer, and summer longer than winter; and while the solar perigee continues as it now is, between the solstice of winter and the equinox of spring, the period including spring and summer will be longer than that including autumn and winter. In this century, the difference is between seven and eight days. The intervals will be equal towards the year 6483, when the perigee will coincide with the equinox of spring; but when it passes that point, the spring and autumn taken together, will be shorter than the period including the autumn and winter."‡

* Geology, p. 13.

† Mrs. Somerville having referred to the authority of chronologists, we subjoin the following from Blair's celebrated chronological tables:—"The creation of the world began, according to Archbishop Usher's calculations, on Sunday, the 23rd of *October*, in the year 4004 before the birth of Christ," a *season* which accords better with what has previously been given, than with what we have just read.—Author.

‡ Connexion of the Sciences, pp. 99, 100.

Reflecting maturely on these interesting evidences, we must be convinced, that *the precession of the equinoxes* is due to an excess in the retrograding action or influence of the sun and moon *on the redundant matter accumulated round the equatorial regions of the earth*, over and above a contrary effect, originating in a small secular motion of the ecliptic itself, caused by the action of the planets on one another, and on the sun, wholly independent of the figure of the earth. The increase of the precession being calculated from an epoch (usually the vernal equinox) when the longer axis of the solar ellipse, by coinciding with the equinoxes, occasioned a perfect equality in the moieties of the year; or, what is the same thing, when the precession was considered to have been 0—an astronomical event which, according to the foregoing authorities, occurred, last, about the period assigned in Scripture, as that of the *formation of the light*, and its *division from the darkness.*

In a previous part of this section, we have endeavoured to prove, and we trust have satisfactorily established, the following two positions:—

1. That during the period of darkness, the earth revolved around the unillumined sun for a sufficient length of time, in geological estimation, to form all the rocky masses which compose its outer crust, until the completion of the independent coal measures. And,

2. That the formation of the light, and its division from the darkness, were the immediate secondary causes of the earth's diurnal rotation; which in turn, caused the protuberance of its equatorial regions, or the excess in the equatorial, beyond the polar diameter.

These two positions, and that established by the precession of the equinoxes, although proceeding from different sources, and different branches of science, are equally well authenticated, but require the adoption of one of the two following suppositions in order to be reconciled to one another, namely, either that the earth revolved around its axis, and assumed its oblate figure from the instant it was translated in space, and experienced precession of its equinoxes from the same period; in which case, it is to be presumed, that the light was formed precisely as it completed a periodical revolution of 20,984

years; or, that during the period of darkness, when all the geological phenomena were forming, it had neither diurnal rotation, equatorial excess of diameter, nor secular retrogradation of its nodes on the ecliptic, but *that all these modifications took place on the formation of the light, and its division from the darkness.*

Now, the adoption of the former of these two suppositions, involves the following insuperable difficulties:—

1. By imagining the diurnal motion to have taken place *before* the geological phenomena were produced, we set aside the only conceivable period for their proper formation, and the only known force, or power in nature, capable of having elevated the continental ridges and mountain chains. Consequently the geological evidences are opposed to this assumption.

2. That by supposing the earth to have had protuberant matter about the equator, *without* diurnal motion, there is involved, as a direct consequence, the destruction of the obliquity of the plane of the equator, to that of the ecliptic, as we have just learned from Professor Playfair's writings.* And,

3. That by conceiving the earth to have revolved round its axis *before* the formation of the light, we do away with the only adequate effect which the formation of the light was calculated to produce, and, thereby, leave a power of such magnitude as the introduction of the principle of expansion into the material universe, without a corresponding effect, or without any effect at all.

On the other hand, by adopting the conclusion come to by us, and admitting—what indeed can scarcely be denied—that the formation of the light and its division from the darkness, caused the rotation of the earth around its axis; that this, in turn, occasioned the terraqueous protuberance of the equatorial regions, and that the action, upon this, of the sun and moon, gave rise to the precession of the equinoxes; the latter phenomena will be found to have commenced *at the same moment as the formation of the light*, the point in *space* coinciding with the epoch in *time*, while a counteracting influence against the destruction of the obliquity of the two planes, will be found

* Playfair's Works, vol. ii. p. 412.

to exist in that which produced the secular disturbance; the whole manifesting the most perfect harmony between the announcements of Scripture, the laws of mechanics, the discoveries and calculations of astronomy, and the researches of geology.

It appears, then, from all that has been said in these sections, *that the primary amorphous rocks, either arose from beneath and perforated the superincumbent stratified masses, or elevated these along with themselves, by means of the centrifugal impetus generated in them by the protorotation of the earth around its axis.* But as the earth could only have once commenced to revolve, and thereby have caused centrifugal impetus, all the rocks found thrust through, or elevating the strata, *must have been moved simultaneously.* Such being the case, there would be a period when the strata over the whole surface of the globe were horizontal, and parallel to each other; and a considerable lapse of time must have been required to have deposited them in successive layers, in the order of superposition in which they are generally found.

Now, if we keep the fact steadily in mind, *that the earth must have been for a long period without rotatory motion,* and blend it with what follows, derived from the first part of the *sixty-seventh* Theorem, which is equally well authenticated, namely, "*That one of the most important qualities of matter in mechanical investigation is* INERTIA, *or that property which results from its inability to produce in itself spontaneous change or action, either from a state of rest to that of motion, or vice versa, to diminish any motion which it may have received from an external cause, or to change its direction.*" Their dexterous combination (while it will be recollected how useful this Theorem has already been) will enable us to arrive at another very important deduction, namely,

That the earth, at one period, not having had rotatory motion; and consisting of inert matter, incapable of generating motion in itself, *a force sufficient to have overcome the resistance must have been brought to bear upon it from* SOME SOURCE EXTERNAL TO, AND INDEPENDENT OF, ITSELF, *before it could have revolved, as it now does, around its axis.* The inertia of the whole mass must have been overcome, before it could pos-

sibly have moved; before the geological phenomena, now displayed upon its surface, could have been produced.

This is a most important conclusion. It reduces us to one of the greatest difficulties ever encountered by men who depend solely on their own resources, to assign *the* adequate cause which overcame the inertia of the world and made it revolve around its axis. *Science knows no such power.* It is only in the Sacred Volume of our Faith that we find any allusion made to the first rotation of the earth, "and the evening and the morning were the first day:" an announcement which must not be looked upon as figurative, but understood in its plain, literal sense—a whole revolution of the earth around its axis in the space of twenty-four hours, or, what is the same, with an angular velocity of fifteen degrees each hour; for, unless this be admitted, and, likewise, that it was its *first* rotation, the necessary centrifugal force would not have been generated; the geological phenomena arising from that impetus would never have existed.

"God said, Let there be light," is the sublime announcement made to man more than three thousand three hundred years ago; and that the light issued forth at His Omnipotent command the whole geological phenomena—within the research of every one, perceptible to the senses, capable of being seen, touched, and believed in—most amply and emphatically attest. So long, therefore, as a peak of granite is visible and tangible to the senses, may the finger be pointed to those monuments of His power, and then to the sacred page, while we exclaim—"Truly did God say, 'Let there be light, and there was light. . . . . . And God divided the light from the darkness. . . . . . And the evening and the morning were the first day!'"

Should any advance in the path of truth and sound knowledge have been made by our endeavours to reconcile mechanical, geological, and astronomical announcements to the sublimer ones of Scripture, it should not be overlooked, that this success will, in great part, be due to the diligent and laborious researches of the followers of those sciences which shall have been rendered instrumental in dispelling those mists which hitherto have hung over this very portion of Scrip-

ture; and that, too, although its validity they, at one time, all but threatened to impugn.

As far as GEOLOGY is concerned we must now take occasion to observe, that having in some degree made reparation to Revelation, it is hoped that its scientific pages may hereafter be approached, not only without dread, but even be sedulously studied by all who earnestly desire the advancement of the truth, and the spread of the only knowledge which can alone prosper and flourish. But, while thus advocating the cause of geology, we should also caution its most zealous and most enlightened followers to beware of future errors. Let them guard against such, and also bear in mind that, without a faith, strong as the evidence of sense, in the announcements of Scripture, their discoveries and their influences will be worse than vain; *they will be positively injurious.* Let them, then, turn with singleness of heart, to the sublime lessons of the Sacred Volume, as the Alpha and Omega of all science: let their zeal, their activity, and their knowledge be hereafter wholly directed to the thorough elucidation of those words, which, though heaven and earth should pass away, will never pass away.

In offering our acknowledgments to ASTRONOMY for the aid it has afforded in establishing the present theory, we also congratulate its disciples on the new and choice field which is afforded them in what it has now been the means of unfolding. We are incapable of fully appreciating the reciprocal lights it may reflect on the vast and the boundless domain of astronomical research, more glorious than any other, and as enriched with variety of phenomena as are the sparkling myriads of orbs which attract their observation. But, while we may be permitted to congratulate them on the anticipations of the future, we would, with all gentleness, remind them of the past; and that they have need of great caution in conducting their enquiries, lest they fall again into error from a disregard to the announcements and the chronology of a Book, which is over, above, and beyond all their calculations and all their observations. Oh! how insensible, to despise the revelations of the Creator of all, at the very moment when they were gazing on His most glorious works, beholding in the magni-

ficent arch of the starry heavens the brightest representative in nature of His radiant and God-like countenance!

Astronomy has indeed a heavy debt to pay to the sublime truths of the Gospel, a debt which has been accumulating ever since Newton's death; and, knowing this, we trust it will now gather together all its resources, and put forth all its energies in order to cancel the obligation. But let it, likewise, remember that, boundless as these resources are, and infallible as the manipulations appear to be which govern its results, yet the Dynamical Theory has proven that, when existing in cold and lifeless separation from Religion, the former *can* be drawn from sources of error, and the latter *have* led to false conclusions.

We, likewise, offer a tribute of thanks for the very important assistance we have derived from the sober and certain science of MECHANICS, which, more conversant with tangible objects, as the ground-work of its conclusions, has revealed the truth, without incurring any errors of hypothesis. But let it rejoice with trembling, and learn to contemplate its own inevitable fate in that which has befallen the sister sciences, should it ever wilfully despise, or willingly lend its aid to any attempt which may be designed to asperse or to impugn the truths of the Sacred Volume.

SECTION VII.

METEOROLOGICAL PHENOMENA RESULTING FROM THE LIGHT, AND FROM THE EARTH'S PROTOROTATION.

CHAPTER XXIX.

Preliminary advertencies. The consequences likely to result from a world of water being thrown into violent agitation and motion by the first diurnal revolution. Longitudinal effects on it of the elevation of continental ridges, and the depression of oceanic hollows. The effects of the introduction of the principle of Expansion into the primeval water. Chemical analyses of water. No Nitrogen in water. No Hydrogen in the atmosphere. Nitrogen traced to its origin in ammoniacal gas. Chemical analyses of this alkaline substance. Free Oxygen—its source. Appropriateness of the juncture, while these elements abounded, for the introduction of Light into the material universe. Philological corroboration of these assumptions. The diffusion principle of gasses requisite to complete the force which expanded the aerial elements to their prescribed boundaries. Meteorological phenomena. Composition of gases in general, and the indestructibility, in particular, of those which constitute the atmosphere.

At the close of the fourth section, we considered the earth to be revolving around the unillumined sun, but without diurnal motion having, as yet, been impressed upon it; while its recumbent rocky crust sustained an equally diffused and universally spread mass of water; which, having undergone a purifying process through many ages, had been deprived of nearly the whole of its earthy and acidulous ingredients, and at the period to which we now allude contained only saline materials; free oxygen maintained in that state by the joint agency of carbonic oxide, and carburetted hydrogen; the primeval water, at this stage of its existence, being likewise saturated with ammonia, which arose from the decomposition

of animal substances, whose living possessors once inhabited infinite numbers of calcareous coverings discovered in the strata, and which ammonia had assumed a supernatent position. It will, likewise, be recollected, that this was the state in which in the subsequent section we supposed it to have been, when it pleased the Creator to issue the successive mandates for the *formation of the light, and its division from the darkness,* whose first and more immediate consequence was *the rotation of the earth around its axis;* while we endeavoured, in that which followed, to unfold in succession the important results which were produced by that memorable and stupendous event upon its rocky masses.

In describing the effects which the movement of its aqueous portion produced, we confined ourselves almost exclusively to those which it exercised upon the broken fragments of the mineral crust. In other words—we merely investigated the results which occurred *underneath,* and were there occasioned by that singular movement of the water of the world. But there were equally important consequences destined to take place in the upper regions of that watery mass, and in its lighter and more gaseous associates, which the division and agitation of the water permitted to escape, and, under the influence of the centrifugal impetus, to ascend, in vapourous expansion, into those vacant regions, whose full extent they were afterwards destined to occupy; and from whence, on this occasion, they were not permitted to return; but being there suspended by the wonder-working power of the Creator, were caused, by his immediate agency, to expand, in the manner we are now about to unfold, into the life-sustaining atmosphere; while their partial elevation, for that purpose, into space by a force so general, and so evidently destined for many other important purposes, as was the centrifugal impetus occasioned by the earth's protorotation around its axis, affords another confirmation of the truth, that nothing is done in vain by the Omnipotent, but that every step in the process of this great work was previously designed by a plan of exceeding wisdom; and executed by an arm of infinite power.

Before endeavouring, by closer inspection into each successive step, to form a juster conception of this magnificent

transformation, performed by the arch-chemist of nature—Nature's God—it will perhaps greatly aid our convictions were we to pause a moment, and imagine, if we can, the grandeur and sublimity of a world of atmosphereless water thrown into violent and uncontrolled agitation, silent and unattended by the slightest noise, in the absence of the vehicle of sound, but greatly augmented in motion by the successive elevation and depression of continental ridges and oceanic hollows, when "at his rebuke they fled, at the voice of his thunders they hasted away;" when they "went up by the mountains, and down by the valleys," or perhaps more emphatically still, "when the mountains ascended and the valleys descended."*

This may, perhaps, be the most opportune juncture for entering into some enquiries with a view to determine, if we can, the relative levels maintained by the primitive water during the first and second days of the Mosaic week, directing our attention particularly to those portions which may be supposed to have rested above the continental ridges, in contradistinction to those which were perpendicular to the oceanic hollows, when their entire mass was thrown into motion by the rotation of the earth around its axis; and afterwards to endeavour to trace the line observed by "the firmament" when it "divided the waters from the waters," or, the level at which that expanse was introduced into the primitive ocean. These questions are not without their difficulties, but, to simplify them as much as possible, let the case be stated thus: A sphere, bearing upon its level surface an equally distributed atmosphereless mass of water of considerable depth, is caused to revolve around its axis with an angular velocity capable of elevating immense continental ridges and of depressing corresponding oceanic hollows, in lines running nearly at right angles to the direction of the rotatory motion, and under these complicated conditions, it is required to know, *how the atmosphereless aqueous portion would be disposed of?*

The question, in our opinion, resolves itself into two separate branches. First. The manner in which the water would comport itself during the time when it was under the influence of

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* Psalm civ. 7, 8, and marginal reading.

the centrifugal impetus, and to a certain extent abstracted from that of gravity? and, secondly. How it would proceed after that impetus had ceased, and the water was restored to the influence of attraction, as far as liquidity admits of its operation?

We prefer going into this investigation, without delaying the general argument by tarrying to enquire, with greater speciality, into the effects which would result from the primitive ocean having been thrown into violent commotion *before* it was circumbounded by the atmosphere; as our reasoning can proceed irrespectively of this, and on the assumed fact, that the work of creation was commenced, carried on, and nearly completed in vacuo; atmospheric pressure having been called in, as a secondary agent, only for those parts which were undertaken and accomplished during the last five days of the Mosaic week. With this advertency we shall continue our discourse.

With regard to the first of the divisions above-mentioned, it is obvious, that there would ensue consequences of a latitudinal, and consequences of a longitudinal character. With respect to the former of these, it has already been shown, in a previous part of this work, that the most natural tendency of the water would be to rush from the poles towards the equatorial regions, in order to assume that state of equilibrium, or of rest, from which it had been roused; and which was necessary in order to complete the form of rotation; while, the difference or inferiority in the velocities of the higher latitudinal zones of water, as they swept towards the equator, by causing them to lag behind, and to acquire a westerly direction, would gradually transform the latitudinal effects into those of a longitudinal character.

Those of a more decidedly longitudinal description are by no means so easily disposed of. They are attended by difficulties, greatly augmented by the paucity of all evidences, or precedents to which we might refer; and, therefore, adhering to that which is next best, we must endeavour to abide by the light of the strictest analogy, and direct our attention steadily to the phases of the other phenomena which resulted from the proto-revolution of the earth around its axis, especially to those

peculiar to its rocky strata, whose solid nature having bequeathed more permanent vestiges, thereby afford us surer data whence to draw conclusions. Our best way, therefore, will be, *to consider the water as the uppermost and most flexible of all the strata which constituted the exterior of the non-rotating earth.*

Now, as the most prominent effects of the protorotation of the earth on its rocky masses was to abstract these, to a certain degree, from the influence of gravity, and thereby to cause them to recede from its centre; we have no reason to suppose otherwise, than that similar results would ensue with regard to the *water*, which, being held together by slighter cohesive attraction, would be more thoroughly comminuted, and consequently relieved to a commensurate extent from the pressure which all fluids sustain from their own body,* and, becoming thereby less dense, would be better adapted for receiving the expansive influence which was so soon thereafter to be introduced into it. At the same time it is necessary to remember, that when bodies of dissimilar densities which are capable of passing or permeating one another, are subjected to the same centrifugal impetus—if this be sufficient to overcome the inertia of the most ponderable—it will throw the heaviest further from the centre, even although it should have previously occupied a position nearer to the axis of gyration. Yet care must be taken not to be led away by this undeniable principle, by applying it without modification, to the singular case which we are at present contemplating, inasmuch as the compact nature and vast extent of area of the continents, and other eminences, evidently show us, that as they could not pass through and change places with the water, they would produce the unavoidable effect of raising up upon their broad extent those parts of the circumfluent ocean which rested upon them, and thus, they would cause, during the prevalence of the elevating force, corresponding inequalities of surface on what had previously been one unbroken spherical sheet of tremulous water. As regards the longitudinal motion on the surface, during the period we are at present contemplating, it appears that a dis-

* According to the 90th Theorem and evidences.

tinction should be clearly made, between that which remained at the original extent of surface, which by revolving with the revolving sphere, would partake of no other motion save that of rotation, whereas, the portion which was caused to ascend beyond those original bounds, by partaking of two motions, that of rotation, and that of ascent, would, according to the composition of forces, have a diagonal direction impressed upon it, in order that it might synchronously comply with both movements.

This is all we intend to say at present with respect to the motion which would take place in the upper or external surface of the primitive water by the rotation of the earth around its axis during the first days of the Mosaic week. But we have still to take into account *that which was going on below;* for, during this period, the rocky masses of the earth were undergoing mighty transformations; immense continental ridges were rising above the original level; and corresponding oceanic hollows were sinking beneath it; while we are warranted in supposing that similar results, modified only by the nature of the water, were taking place in it also to a certain extent. No one can imagine the continent of America, for example, to rise up from beneath a level plane of water, however deep it may have been above it, without causing a corresponding watery ridge or wave along the whole of its surface. And, in a corresponding manner, those portions of the primitive water which were perpendicular to where the depressions were made for the beds of the ocean, must have sunk along with that on which they rested; while the centrifugal impetus, being equal for all points on the same parallel of latitude, its longitudinal effects, in modifying these inequalities of surface, may be considered inappreciable. It is, therefore, presumed that matters would remain in this state during the whole of the first revolution which the earth performed around its axis: for it has been shown that was the period during which the rocky masses of the earth were elevated and moulded into their present diversity of form.

This brings us to the consideration of that which is supposed to have taken place during the *second* day of the Mosaic week. If we recur to the Record, we shall find that the first command

issued on that day—when the centrifugal impetus, which was impressed during the day previous on the waters, is supposed to have reached its maximum—was "Let there be a firmament (or expansion) in the midst of the waters; and Let it divide the waters from the waters;" and when we consider that the expansive force which caused the rotation of the earth, and which had acted in a tangential direction, was now employed to stretch out the firmament, and that the lower plane of this must have cut the water near to where it is at present, we shall at once recognise the perfection of that wisdom, which disposed the water of the primeval ocean to be raised into enormous longitudinal masses or waves, in order that the vaporization should be greater above the continental ridges, where it was so essential that the water should be evaporated, and not be *drained* off; while the same operation was comparatively trivial in and over those portions corresponding to the parts which now form our seas, where vaporization was not required; and when, in addition to this, we further consider that the shallowness and the increased temperature of the former—occasioned by the introduction into them of immense continents of heated mineral—would pre-dispose them to accelerated vaporization,* we shall have still greater cause to admire the infinite Wisdom which directed the whole.

There is another branch of our subject intimately connected with this, which, if left any longer unnoticed, may, perhaps, lead to disquieting doubts hereafter. To prevent this, we shall dispose of it at once. We allude to what cannot be denied. *The existence in the universe of the principle of expansion, long previous to the formation of the light, as it is now constituted.* To this we have frequently alluded already, as the only assumption in accordance with which it can be supposed, that the "waters" maintained their liquid state, and were not solidified into one impervious sheet of ice; or that the spheres pursued their distinct orbits in space, and did not

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* This is confirmed by a passage in Hutchinson's Principles of Meteorology, p. 27, et sequiter, and by another in the "Introduction to Meteorology," 1849, p. 98, et seq.

concrete into one vast impenetrable mass—a universe of undivided matter! Our present enquiry not being connected, however, with any disquisition as to the *source* from whence that expansion emanated previous to the formation of the light—which has already been fully and freely discussed—but rather to the *quantity* introduced into our planet, it is presumed we may with this proviso safely dispose of the question; assured that its existence in the universe previous to the formation of the light is not hypothetical, but based on the sure word of Revelation, and that, whatever may have been the amount of the *expansive principle,* which was introduced during the period alluded to, it would be no more than precisely adequate for effecting the objects which were then contemplated. As none of these, however, had any reference to the *expansion* of the atmosphere, they do not come within the legitimate limits of our present enquiry; while, considering the Omniscient source from whence the principle of expansion emanated, during the progressive development of the work of Creation, it will readily be admitted, that the quantity of that penetrating and fostering principle which was imparted would be proportioned to the well-being and perfection of the whole. On this all-prevailing truth we may repose with every confidence.

It becomes necessary now, to direct the attention to a few preliminary explanations, which, although they may appear somewhat disconnected, will serve, nevertheless, to render our future argument more continuous and uniform; and, besides, by storing the mind with these requisite notices, they will make what we have hereafter to bring forward more easily understood. Like the magnificent operation which we are about to unfold, for which all the ingredients were anteriorly stored up, ready to be combined and form the atmosphere—by our having a knowledge of these elements in our minds, the account of their subsequent combination, into one grand and harmonious whole, will be rendered more thoroughly convincing, and the grandeur and wonderful wisdom of the operation more readily and clearly perceived.

In conducting these succinct enquiries, our first care shall be

to explain, not only the more intimate composition of water itself, but also the state in which its elements exist in it, when in combination.

"Water," says Mr. Reid, "it must be borne in mind, is a *true chemical compound.* It is not a mere mechanical mixture of elements, in the way in which air is a mixture of oxygen and nitrogen. A mere mixture of oxygen and hydrogen has not the properties of watery vapour, and before they can be made to form watery vapour they must be made to enter into chemical union by having a considerable degree of heat applied to them, or by being strongly compressed; none of which are at all necessary to cause a mere mixture of oxygen and nitrogen to have all the properties of air. There is a great *change* of properties, which is not the case with the oxygen and nitrogen of the air. When combined with the hydrogen into watery vapour, the oxygen has lost entirely its power of supporting combustion and respiration, although it is present in watery vapour in a far greater proportion than in air, and it is not easy to withdraw it from the hydrogen, being united by a strong chemical attraction; while the hydrogen has lost entirely its inflammability, and both have become so much altered that they are easily condensed into the liquid form, which cannot be done with either of them when separate; there is a change of bulk, for the quantity of vapour formed by a certain proportion of oxygen and hydrogen, occupies less space than the two gases separately; and heat and light are produced when they combine, a sure mark of chemical union. In this respect, water, as contrasted with air, forms a striking example of the difference between *combination* and *mixture.*

"It is also to be observed, that the water thus produced, is to be regarded *as a compound of hydrogen and oxygen, not of hydrogen and oxygen gases.*"*

"Water," says Mr. Graham Hutchinson, "is composed of hydrogen and oxygen, the former being the strongest electro-positive, and the latter the strongest electro-negative element known."†

Mrs. Somerville confirms this when she says—

"Voltaic electricity is a powerful agent in chemical analyses. When transmitted through conducting fluids it separates them into

* Popular Chemistry, p. 101.

† Principles of Meteorology, p. 160.

their constituent parts, which it conveys in an invisible state through a considerable space or quantity of liquid to the poles, where they come into evidence. . . . . . Suppose a glass tube filled with very pure water, and corked at both ends; if one of the wires of an active voltaic battery be made to pass through one cork, and the other through the other cork into the water, so that the extremities of the two wires shall be opposite and about one quarter of an inch asunder, chemical action will immediately take place, and gas will continue to arise from the extremities of both wires till the water has vanished. If an electric spark be then sent through the tube, the water will reappear. By arranging the experiment so as to have the gas given out by each wire separately, it is found that water consists of two volumes of hydrogen and one of oxygen. The hydrogen is given out at the positive wire of the battery, and the oxygen at the negative."

And in another part of the same work she thus expresses herself—

"The law of definite proposition, established by Dr. Dalton, on the principle that every compound body consists of a combination of atoms of its constituent parts, is of universal application, and is, in fact, one of the most important discoveries in physical science, ... in disclosing the relative weights of the ultimate atoms of matter. Thus, an atom of oxygen, uniting with an atom of hydrogen, forms the compound, *water;* but, as every drop of water, however small, consists of eight parts by weight of oxygen, and one part by weight of hydrogen, it follows, that an atom of oxygen is eight times heavier than an atom of hydrogen."*

"When water," says Dr. Thomson, "is pure, it is found to contain an equivalent of hydrogen, and one of oxygen, consequently, it is a chemical compound whose atomic weight, in this country, is represented by 1—8.013=9.013, i.e. the combining proportions of these gases are in the ratio of 1 to 8.

"Its composition may be shown either by analysis or synthesis. By the former it is decomposed into its respective gases, in the relative weights mentioned, or by *volumes* into two of hydrogen and one of oxygen; by the latter it is produced when these gases are mixed in the proportions stated, and an electric spark transmitted.

* Connexion of the Sciences, pp. 310, 311, 122.

. . . . . It is entirely neutral, having neither acid nor alkaline reaction."*

It will have been perceived, from what has now been transcribed, that water in itself contains no nitrogen; but, as this constitutes nearly four-fifths of atmospheric air, we shall have to search for this predominant ingredient in some one of the substances with which the primitive ocean was considered to have been saturated. Now, ammonia is partly composed of nitrogen, and taking for granted, from what has been fully explained in previous parts of this theory, that *where* animal life abounded, and became extinct, *there* ammonia—one of the most copious exhalations arising from animal decomposition—must likewise have abounded; we shall go on to enquire into its composition, and the capability of water to become saturated with it to an almost unlimited extent.

"This alkali," says Dr. Murray, when treating of ammonia, "obtained by indirect processes, was known to the older chemists only in its combination with water, forming the liquid, which, from its volatility compared with the other alkalis, was denominated *volatile alkali*. Dr. Priestly first showed that a gas can be procured from this liquor by a moderate heat, and that the pure alkali is a permanently elastic fluid. It is therefore called ammonia, or ammoniacal gas, and its solution in water is called liquid ammonia.

"The proportions of nitrogen and hydrogen which form ammonia, according to very careful experiments made by Dr. Henry, are precisely *three* volumes of hydrogen, and *one* volume of nitrogen, in conformity with the usual simple law of volumes. . . . . . Ammoniacal gas is largely and rapidly absorbed by water; the water, under a mean atmospheric pressure and temperature, taking up, according to Sir H. Davy, 670 times its bulk of gas. It is under the form of a watery solution that ammonia is usually employed as a chemical agent. . . . . . It unites with all the acids forming neutral salts, which are all soluble and crystallizable, and have an acid taste, though they retain in some degree, the properties of the base."†

"The substance called ammonia," Dr. Lardner observes, "was

* Introduction to Meteorology, 1849, pp. 132, 133.

† Chemistry, vol. ii. pp. 6—15.

only known as a gas until a temperature of 46° was attained. Exposed to that temperature it became a liquid. Such a body, in high latitudes, would, at different seasons, exist in the different forms of liquid and gas; in winter it would be liquid, and at other seasons gas."*

"A cubic inch of water," says Mr. Hugo Reid, "could absorb 670 cubic inches of ammoniacal gas. . . . . . By its property of absorbing gases, water is very useful to the chemist. For, by this means he can lay up a store of any gas, and preserve it for some time for use. . . . . . When water dissolves a gas, the bulk of the gas is frequently little, if at all altered, so that the two together occupy much less space than when separate; and hence the solution must be heavier than water. The reverse, however, is the case with ammoniacal gas; the specific gravity of water, which has absorbed as much as it can of this gas, is 0.875, that of water being 1,000."†

"In volcanic countries," Mr. Donovan states, "a mineral is found which occurs in crystals, and in masses of a greyish, yellowish, or brownish colour; its taste is sharp, burning, and saltish. . . . . . This is called *sal ammoniac*, it holds the alkaline gas in its substance; it is its base; and the alkaline gas has been named *ammonia*, or ammoniacal gas, from the salt which gives origin to it. Water absorbs upwards of 600 times its bulk of this gas, and acquires some of its properties; hence the compound is called *liquid ammonia*. During the absorption of ammoniacal gas by water, the liquid becomes hot; for the caloric which was latent in the gas, and maintained it as such, becomes sensible as soon as the gas changes its state to that of a liquid, according to a law already explained; hence the temperature rises. At the same time that the gas is thus absorbed, the solution suffers a permanent expansion, for the resulting liquid is specifically lighter."‡

"According to Baron Liebig, "says Dr. Thomson, "there is always present ammonia—composed of 1 volume of nitrogen and 3 volumes of hydrogen, condensing into 2 volumes—derived from the decomposition of animal matters, from which gas the nitrogen of plants is supposed to be obtained. From the great affinity of ammonia for water, it will not be found *free* in a humid atmosphere. . . . . .

"According to Gieger it exists in the atmosphere in combination with carbonic acid."§

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* On Heat, Cab. Cyc. p. 178.

† Popular Chemistry, p. 108.

‡ Chemistry, in Cab. Cyc. pp. 112, 113.

§ Introduction to Meteorology, 1849, p. 5.

The existence of *free oxygen* in the primitive water, is not very easily proved in a *direct* manner, although it can be effected by the soundest inferences. For as *water* was the only source from whence all those existences, which were generated in it, derived their gaseous elements, these, consequently, were mere modifications of that original element; while, as far as regards our present argument, it matters not through how many intermediate transitions they may have passed, provided we can at last detect them in such a form as to show, that the proportions of their elemental ingredients are different from those of *water*.

Now, we know, that this all-pervading element is composed of one volume of oxygen, and two of hydrogen, in the relative proportions of 8 to 1, in weight; and as ammonia consists, we have seen, of three volumes of the latter, and one of nitrogen, it follows, that in the formation of this ingredient alone, which we have chosen for an example, we can account for the liberation of much oxygen. The same might be done with many other substances. Again, if without taking into account the great proportion of hydrogen which enters into the composition of plants, we should merely bring to mind their activity in decomposing carbonic acid (with which the primeval water abounded)* in order to fix the carbon, and *liberate the oxygen;*† and then consider the prevalence of submerged vegetable existences—now constituting the coal measures—which suddenly became buried beneath the debris (occasioned by the protorotation of the earth), and which were prevented from giving out the exhalations common to their decaying state—and reflect on the effects of the continued introduction into the water, from the previously decaying substances, of carbonic oxide, and carburetted hydrogen, which would tend to keep the oxygen, thus liberated by all these agents, free from combining with any other substance, or re-entering into spontaneous combinations without the aid of animal or vegetable secretion—it is presumed, that in these combined causes we shall find sufficient reason for admitting—indeed, for not being able to deny—that towards the close of the non-rotating period

* Theorem 36.

† Botany, by Professor Henslow, Cab. Cyc.

of the earth's existence, its circumfluent water was abundantly saturated with *free oxygen*, whose presence was so essential for the formation of the atmosphere, and for accelerating the oxydizing process in forming the soils, when the elevation of the continents and the separation of the land from the water took place.

We have endeavoured, by these concise explanations, to trace the origin, and to show the existence, towards the close of the non-rotating period, of the requisite ingredients for the great work which was next to occupy the attention of the Creator—*the formation of the atmosphere;* while we cannot withhold our admiration from the wonderful adaptation of the receptacle which was selected for storing up those ingredients, *an ubiquous mass of water capable of retaining, and ready to give them out wherever and whenever required.*

It is always delightful to contemplate the fitness of the means to the end, and the vastness of the scale on which the wonders of the creation were conducted by the Omnipotent; but the present affords us more than the usual degree of gratification, from its attendant circumstances being more apparent, and within the grasp of our intelligence. When made aware of the design, we at once perceive that nowhere could a more adequate receptacle have been found in which to accumulate and to preserve the gases requisite to form the aerial ocean which now floats around and above us, than a mass of circumfluent and atmosphereless water, everywhere equally proximate to the space above them, which was destined to be filled by these subtile elements, when once they should be associated with the principle of expansion, to confer their buoyancy upon them, and to fit them by mechanical union, and in suitable proportions for becoming *the life-sustaining atmosphere.*

Being fully persuaded of these sublime truths, and having present to the mind the state of elevation and dispersion in which the primeval water was maintained by the centrifugal impetus, under whose dominion they are considered to have been at this epoch, let us turn to the records of Scripture, and we shall find it there written, that "God said, Let there be a firmament in the midst of the waters, and Let it divide the waters from the waters." After which it is immediately

added by the inspired historian, "And God made the firmament, and divided the waters which *were* under the firmament from the waters which *were* above the firmament: and it was so. And God called the firmament Heaven. And the evening and the morning were the second day."

All who reflect maturely on what has now been stated, will acknowledge, that this was the juncture most consistent with infinite wisdom for effecting the permanent alliance between the radicle of the gases accumulated in the water, and the expansive principle with which they are combined, and which transformed them into aerial gases. Whether the ocean was saturated, as we have supposed, with free oxygen, or whether the water itself was decomposed to supply it, does not in any way affect the wisdom which chose the *period* for transforming those radicles into gaseous elements; when the mass of water was still maintained by the influence of the centrifugal impetus, high above the land and their own present level; and when, at the same time, they were much dispersed and more easily penetrated by the light, which conferred on them their permanently elastic state; and, therefore, the fact of this being the juncture recorded in Scripture, for the formation of the atmosphere—whether from elements in or associated with the primeval water—when these were under the influence of a centrifugal force of such power as would be engendered by the rotation of the earth, at the conclusion of the first day—stamps the impress of truth on it, and assures us in language—which can neither be mistaken nor set aside—that infinite wisdom planned and executed the whole.

According to a fundamental doctrine in natural philosophy, which forms the subject of the *fifty-first* Theorem, there are two antagonistic forces called *attraction* and *expansion* which seem to unite with and to govern the intimate relations of the molecules of all bodies; the one force exercising its influence in just so far as the other is absent, or that it predominates over it. Now, according to that doctrine, which forms one of the principal bases of this theory; and conceiving that the dominion of expansion, arising from physical light, was only being established—if we may be allowed so to express ourselves—out of the domain which previously had been under

the government of attraction; we apprehend the command just cited, to have had the following implied meaning; "*Let the principle of Attraction be again so far encroached upon, as shall permit the formation of the firmament by the union of that of Expansion with certain elements of or associated with the water.*" It being understood, however, that agreeably to the general plan of the creation, it was necessary that the command should be given *in the precise terms in which it is recorded,* the above paraphrase being offered merely in explanation of the views adopted of the progressive development of the work we are contemplating. If this exposition be correct we should find it corroborated as well by philological testimony, as by the more tangible evidences of practical philosophy. From both of these sources convincing proofs can be adduced. We shall commence with the philological evidences, in order to prepare the mind, and to leave it more disengaged for future argument.

"We have always," say the Editors of the Presbyterian Review, "regarded the Mosaic description of the formation of the atmosphere as one of the most remarkable passages in the whole history, and as betraying a knowledge of the constitution of the aerial fluids far above that to which unaided reason could have attained, at least at the period when the Scripture narration was penned. To see the full force and beauty of the description, however, it is necessary to study it in the original language. When rendered literally and etymologically, the meaning of the original words may be translated into English as follows:—'And God said, Let there be expansion in the midst of the waters, and let it be a separating between waters into waters.' That is, let the expansion effect a separation *between waters* which are now in combination, and that *into waters* which are hereafter to exist in a state of separation. 'Then made God the expansion, and separated between the waters which (were) from under the expansion, and between the waters from above the expansion.' That is, He made a separation, not only *between* the waters from under the expanse, and those from above it, but also *between* the waters from above the expanse themselves. 'Then called God the expansion heaven,' (or etymologically 'fire waters'). This name which God bestowed on the expansion sufficiently indicates the nature of the process. It is a compound made up of the

words 'fire' and 'water,'* thus denoting that the expansion was formed by a combination of the elements of fire and water; watery vapour is a combination of water with the elements of fire; but the expression was more than this. It was to be formed by a separating between waters, and into waters—the waters were to be decomposed and formed into separate waters, which being united to the elements of fire, were to constitute the fire-waters, or heavens. Now, this is the very process that must have taken place before the atmosphere could be formed from the original waters. The expansion, be it observed, was not a creation, such as the original material of the heaven and earth. God *created* the latter, but He *made* the expanse, that is, formed it of previously existing materials: and these previously existing materials, we are told, were those of water. Now, one of the principal ingredients in water is oxygen gas, which forms eight-ninths of its whole weight. The same gas is that ingredient in atmospheric air from which it derives all its most important properties, as a supporter of combustion, and of animal and vegetable life. The other ingredient in the atmosphere is nitrogen gas, which might, as a constituent of the original waters, have existed in many ways. Before these gases could be extricated from the waters, it was necessary that that fluid should be subjected to decomposition, so as to yield the oxygen gas of the atmosphere; and, to enable the gas to assume its aeriform state, it was necessary that it should be united to a large additional proportion of the elements of fire. . . . .

"The Hebrews, we may observe, have no word exactly corresponding to our words *air* or *gas;* neither have they any general term, such as our word *fluid*, expressive of bodies in that particular state in which their particles are perfectly mobile. They seem to employ the term *waters* in a somewhat wider sense than we do, applying it to fluids in general. When it is said, therefore, that there was to be a separation between waters into waters, we should rather understand the word in the wider sense, and render it, 'between fluids into fluids;' the fluids into which the water was to be separated being the two elemental gaseous fluids of which water is composed. This view is certainly countenanced by the name *fire-waters* or *fire-fluids*, which was given to the heavens.

"We have already mentioned, that there is reason to suppose that the atmosphere, as now constituted, was not finished on the second

* The Hebrew words are given in the Review, but as the evidence will be equally conclusive without them we have suppressed them here.—AUTHOR.

day. This has been inferred from the want of the words of approval, 'And God saw that it was good or perfect.' These words are applied to the work of every day but the second; and if there was any reason at all for the omission, the most rational one to assign is, that the work which was accomplished that day was not a perfect work, but required something to be added to it before its Maker could pronounce it good. . . . . .

"We stand upon the broad fact, that Moses describes the formation of the atmosphere as having been accomplished by an expansion, a separation from the waters of separate waters, and his giving to these last the name of *fire-waters;* and we say, that such a description indicates a knowledge of the natural constitution of the waters and the atmosphere, far above that which the rest of mankind for ages possessed; a knowledge, we might add, which flesh and blood could not reveal to him, and is a passage in all respects worthy of being classed with the profound exclamation of Job—'Thou stretchest out the north over the empty place, and hangest the earth upon nothing.'"*

With the exception of the misapprehension as to the *condition* in which oxygen and hydrogen—not their gases—exist in water, which has been incurred by the reviewers, and the mere passing allusion to the existence of the nitrogen, this evidence is satisfactory, and perhaps does as much as any quotation purely philological *can* do to satisfy the mind. It will be thought still more so when we have examined those branches of science with which it is connected. Before we proceed to do this, however, let us attend to a few general observations to prepare the mind, and to show the extreme difficulty of the field of research on which we are now about to enter. With regard to the former, we have only to observe, that in whatever manner the principle of heat and light may have been combined with the gaseous bases so as to fit them for becoming the components of the atmosphere, one thing seems perfectly obvious, namely, *that during the execution of the operation in question, there must have been an ascent or movement upwards of the molecules of matter;* for neither the water nor its elements could have been raised by *the centrifugal impetus* to

* Presbyterian Review, No. xv. pp. 359—363.

the height of 40 or 50 miles above the earth's surface, to which the upper limits of the atmosphere now extend. Therefore, there must have been, as has just been stated, a movement of matter *upwards*, or contrary to the direction of gravity, until the elements of the atmosphere reached their destined limits. We beg that this general truth, which is in itself so undeniable, may be borne in mind, as we shall have occasion to refer to it again during the course of our argument.

With respect to the other observation we proposed to make, namely, the difficulties attending the study of this subject—these, even when the investigation has been into the laws of an atmosphere *already formed*, are so well, and so appropriately expressed by an eminent writer on the subject, that we offer no apology for using his own language on the occasion; anything we could have written would, indeed, have been merely a modification :—

" The real state of things," says Professor Whewell, when treating of the watery vapour, " which we enjoy, the steam being mixed in our breath and in our sky in a moderate quantity, gives rise to results very different from those which have been described. The machinery by which these results are produced is not a little curious. It is, in fact, the machinery of the *weather*, and, therefore, the reader will not be surprised to find it both complex and apparently uncertain in its working. At the same time some of the general principles which govern it seem now to be pretty well made out, and they offer no small evidence of beneficial arrangement."*

And again—

" The varying occurrences thus produced, tend to multiply and extend their own variety. The ascending streams of vapour carry with them that *latent heat* belonging to their gaseous state, which, when they are condensed, they give out as sensible heat. They thus raise the temperature of the upper regions of air, and occasion changes in the pressure and motion of its currents. The clouds, again, by shading the surface of the earth from the sun, diminish the evaporation by which their own substance is supplied, and the heating effects by which currents are caused. Even the mere mechanical effects of the currents of fluid on the distribution of its own pressure, and the

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* Bridgewater Treatise, p. 98.

dynamical conditions of its motion, are in a high degree abstruse in their principles and complex in their results. It need not be wondered, therefore, if the study of this subject is very difficult and entangled, and our knowledge, after all, very imperfect."*

And a more recent and no less intelligent writer has the following apposite transcriptions which, with his guarantee attached to them, we adopt as additional evidence:—

" Never," says Arago, " whatever may be the progress of the sciences, will the *savant* who is conscientious and careful of his reputation, speculate on a prediction of the weather."

And, once more, to quote the eloquent words of Sir David Brewster—

" In the very atmosphere in which he lives and breathes, and the phenomena which he daily sees and feels, and describes and measures, the philosopher stands in acknowledged ignorance of the laws which govern it. He has ascertained, indeed, its extent, its weight, and its composition, but though he has mastered the law of heat and moisture, and studied the electrical agencies which influence its condition, he cannot predict, or even approximate to a prediction, whether, on the morrow, the sun shall shine, or the rain fall, or the wind blow, or the lightnings descend. 'The wind bloweth where it listeth, and thou hearest the sound thereof, but canst not tell whence it cometh or whither it goeth.' "†

If the study of the machinery of the weather, when contemplated in an atmosphere already formed, appears so arduous, what must be the difficulties of those who undertake to explain its original formation?

To proceed with this enterprise, however, difficult as it may be, let us now learn the nature of the Atmosphere itself, as revealed to us by experimental philosophy.

The *eighty-fourth* Theorem states, "*That the* ATMOSPHERE *is an aerial ocean surrounding the earth in all directions, and of which the surface of the land and sea forms the bed. That its density diminishes with extreme rapidity as it proceeds*

* Bridgewater Treatise, pp. 103, 104.

† Introduction to Meteorology, by Dr. Thompson, pp. 439, 440.

upwards; and, eventually, at a height not exceeding fifty miles, reaches a real and definite boundary. That this upper surface is estimated to be precisely where the specific elasticity of the air is balanced by the power of gravitation. And, that the mean temperature of space is considered to be 58° *below the zero point of Fahrenheit.*"

The truths contained in the Theorem which has been recapitulated, are of so rudimentary a character that they require no confirmation. We shall, therefore, go on to give the information contained in that which immediately follows:—

"*That the* ATMOSPHERE *is composed of aerial fluids, chiefly oxygen and nitrogen, in the ratio of one volume of the former to four of the latter; or, more correctly, one hundred parts of atmospheric air contain* $20\frac{8}{10}$ *of oxygen and* $79\frac{2}{10}$ *of nitrogen. It also contains variable quantities of carbonic acid gas and of aqueous vapour. That the two first of these have never either been liquidized or rendered incandescent*; *while the amount of moisture varies according to the dew point and state of the barometer. That although in certain states it is* 815 *times lighter than water, it exerts a pressure on the surface of the earth equal to* 15*lbs. for every square inch: a pressure which prevents the sun's rays from converting water and all other fluids into vapour. That it is permanently elastic, its tension increasing in proportion to its density; admits of considerable variation in the quantity of its associated watery vapour*; *and, that a gas and a vapour, occupying the same space, have a tension equal to their combined tensions.*"

Having acquired this requisite information, let us conceive, that, through the effects of the centrifugal impetus, the water was considerably dispersed, and its associated elements separated into minute particles of oxygen and liquid ammonia; and, that at this very juncture, the command "Let there be a firmament, or expansion in the midst of the waters," was issued, and then endeavour to follow up the consequences of light, heat, or electricity—the principle of expansion—having been combined with the elemental ingredients thus put into violent agitation.*

* We have been strongly confirmed in this view by the following paragraph

Perhaps the most perspicuous manner of treating the subject will be to consider it in separate parts. To take up, first, the aerial portion of the atmosphere, apart from its aqueous associate, and endeavour to trace its formation, by the union of light with the elements of which atmospheric air is composed. And, in continuation, to consider, that the same expansive principle was subsequently made to combine with water so as to constitute the aqueous or vaporous portion of the great aerial ocean which now floats around us, dispensing life and vigour to all within its influence.

Closing in by degrees from these more general conceptions, we must, first of all, bring to mind, *that the air has no hydrogen in its composition, and that water has no nitrogen, while we know of no process whereby the one can be transformed into the other.* This will simplify the question very much ; it will enable us to eliminate the hydrogen of the water entirely from our attention when we are considering the constitution of the atmosphere itself; while it constrains us to restrict our researches for the required nitrogen or azote, entirely to the ammonia, with which the primitive water is supposed to have been so abundantly saturated towards the close of the non-rotatory period.

When it is taken into consideration that " water can absorb 670 times its own bulk of ammoniacal gas," and that the relative density of the oceanic water, when compared with the atmosphere, may be estimated by the fact, that the latter exerts a pressure on the surface of the globe, as if, instead of air, it were enveloped with water only to the height of 34 feet above the surface ;* it is presumed that these assumptions are quite consistent with the nature of all the elements supposed to have been then present.

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with which Dr. Thomson concludes his recent and excellent volume on Meteorology, published years after the above was written :—

" The various meteors described," says he, " are not the offspring of separate causations, but functions of common principles. The intimate agency of heat and electricity is apparent in the *tout ensemble* of the science. The former is the *primum mobile* of Meteorology, and oxygen, nitrogen, and hydrogen are the elements on which it operates." (Introduction to Meteorology, 1849, p. 440).

* Reid's Popular Chemistry, p. 31, and Dr. Thomson, p. 444.

Expansion, or the expansive principle, is assumed to emanate from, or to be a diversified manifestation of light and heat. These, in turn, are considered to be identical with electricity, and capable of being made to produce, under certain circumstances, similar effects.* But whether we designate this principle by the name of light, heat, electricity, or expansion, one thing regarding it, as far as our present argument is concerned, is alike certain—*that it came from some source altogether beyond, and, therefore, wholly independent of the water.* The command is quite special with regard to this, and would not have been given had the expansive principle previously existed there. "Let there be expansion in the midst of the waters," is the clear and specific command. Again, that it did *not* reside in the solid portion of the globe, or underneath the water, we consider to have been already made sufficiently evident.

Therefore, we must conclude, as above, that it came from some exterior source, entirely foreign to either. And, consequently, on reaching the water from without, whether it acted as a tangential, or as a direct force, although we assume it to have been of the former description, it must, according to the regular order of causes, *have come first into contact with the uppermost strata of the water.*

Even should it be deemed superfluous, we cannot, we think, too frequently impress upon our readers, that we are treating of a period when the light was not, as it is now, imparted "in measured quantities according to the angular velocity with which the earth passes round the sun," *(second Theorem)*, but that this subtile fluid—which had not yet been made to assume its visible state—was under the immediate controul of the Almighty, who was, as it were, employing it as a material *primum mobile* to complete the work he was engaged in; and, in effecting this, was imparting it, to the several previously prepared materials, in the way, and to the extent which was most accordant with infinite wisdom, and with his own eternal decrees. It is also specially to be observed, that the light, heat, or expansion which was imparted

* Theorems 64 and 74, to which please refer. Also to Thomson's Meteorology, p. 278.

to any of his creations—be what they may—during the Mosaic week, were endurable impartations, never thereafter, so long as sun and moon exist, to be separable from them and their descendants, but to constitute a part and portion of their component structure: from which our readers will understand, that it was not like the rays of the sun, which warm merely while they shine, *but the fixation of the buoyant principle once and for ever as a normal characteristic of the thing then made;* with regard to the inanimate part of creation, in a manner analogous, though in a wonderfully different way, to the living principle which was imparted to the inert materials which form animated creatures. Neither was the expansion of the *second* day merely a natural effect of the light of the *first* day; but it was *that* light, then willed into existence, specially employed for the specific object in view during each successive stage of its action, and imparted only in the manner and to the extent which was requisite. The primary light, by being divided from the darkness, caused the spheres to revolve; but had no command been given on the second day, it might, for ought we know, have produced no further effect. The succeeding exercise of its influence, by the fiat of the Omnipotent, formed the atmosphere; and the next, separated the waters from the dry land; but we are to understand all these to have been *special acts*, for whose accomplishment a determinate command required to be given; and without which they would not, as *natural effects* of the primary light, ever have taken place; in fine, the expansive principle might never have come into contact with the waters; but as it was, we understand that *it first impinged upon their uppermost strata.*

Now, we have just been endeavouring to show, that the uppermost portion of the primeval water was saturated with free oxygen and ammonia; and, mark what follows: it is asserted by an eminent practical chemist, "that on the introduction of electricity into ammonia, where oxygen is likewise present, *water is formed and nitrogen is liberated.*"* Thus, by being made aware of the appropriate arrangement of these elements in the great laboratory of nature, and of the intro-

* Dr. Ure's Chemical Dictionary, p. 151.

duction of the principle of expansion, all under the superintendence of our benignant Creator, we behold with admiration and gratitude, the purpose for which it pleased Him, who doeth all things wisely and well, to prepare a reservoir of nitrogen, sufficient to form four-fifths of the whole atmosphere, in order to dilute the oxygen, which was in due time to be added to it, for the respiration of myriads of creatures yet unborn; as well as the manner, no less simple and elegant, by which the oxygen destined to complete the elements of the atmosphere, was liberated from the fluid in which it had been stored up. For it is asserted by a French chemist, as the result of one of his operations, that on *applying heat to a quantity of water impregnated with a double volume of oxygen, the super-proportional oxygen is driven off, while the water itself remains in its original state.* By this we behold another of the designs why heated mineral masses, composing the continents of the earth, were introduced into an ocean surcharged with the oxygenous elements of a world's atmosphere!

The contemplation of such mighty operations, conducted with so much wisdom, must afford to an unprejudiced mind the most exquisite satisfaction and delight. And, when we add to these the consideration of the facts, that an agent so subtile, and whose effects are so soft and impalpable as light, was made use of; and that a body so admirably adapted as water for receiving, without transmitting the effects of the percussion, was caused to intervene between the impulse and the terraine portions of the earth, the entire arrangement affords a perfect illustration of the surpassing wisdom which designed and executed the whole.

But we have still to trace the more permanent effects of the introduction of the expansive principle into the water of the primeval ocean. Its first results we have just been made acquainted with; we must now endeavour to discover how these gaseous bases were transformed into the elements of an aeriform fluid so pre-eminently elastic as the atmosphere. With this design we shall employ whatever evidences are afforded us by the researches and the discoveries of chemists; while it may serve to heighten our admiration, if we should reflect, that previous to the formation of the atmosphere itself,

whose very elements we are endeavouring to trace to their source, or, in consequence of its non-existence, the combining power of light and heat would be considerably augmented:* that is, the power, or the combining influence of light would be an entire atmosphere, greater than what the rays of light can now exercise in uniting with, or in conferring their effects upon any substance which they may be employed to transform under the existing pressure of the atmosphere.

The *eighty-sixth* Theorem states, "*That every gas has, at least, two ingredients in its composition, namely, some gravitating matter, which may be called its base or principal part, and the subtile fluid, caloric or heat, and perhaps light and electricity; which, when present in sufficient quantity, cause the base or radicle to appear in a gaseous form.*" The following are some of its evidences:—

"Bodies," observes Dr. Lardner, "existing in the aeriform state, are divided into two classes, called *vapours* and *gases*, ... the latter are those aeriform bodies which have never been known to exist in any other than the aeriform state, and which, under all ordinary degrees of cold, preserve their elastic condition. This class includes common air, and a great number of substances known in chemistry, under a variety of names, but all comprised under the general denomination of *gases*. . . . . Such bodies would maintain all the gaseous qualities which they are observed to possess at present, though they should be true vapours, capable of being condensed, and even solidified, if we possessed practical means of depriving them of a sufficient quantity of heat which they contain. For, in proportion as more powerful means of extorting heat from gases has been invented, a greater number of them have been forced within the limits of the law of condensation. . . . .

"Since it is certain, that *gases* may lose a considerable quantity of heat, without undergoing any degree of condensation, we must look upon them as vapours; which, besides the sum of the latent and sensible heat necessary to sustain them in the elastic form, have, subsequently to attaining that form, received a large accession of

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* No less than 124° of Fahrenheit's Thermometer. And according to Robinson, fluids boil in vacuo at 140° lower than in the open air. (Thomson, p. 18).

heat; and yet, from their nature, with all this supply of heat, their temperature does not exceed the ordinary temperature of the globe."*

Although the following evidence, on the same point, is abstracted from a part of Mr. Donovan's treatise, in which he endeavours to controvert the Lavoisierian theory of combustion, it nevertheless corroborates what we are at present seeking to establish, and shows, very manifestly, the opinion of the celebrated French chemist, with respect to the composition of gases:—

"One of the most remarkable, important, and least understood phenomena in nature," says Mr. Donovan, "is the process of combustion. It has unsuccessfully occupied the attention of philosophers in all ages; and, even at this moment, the chief difficulty remains unexplained. . . . . . The theory which, of late years, has occupied most attention is that of Lavoisier."

After going somewhat into particulars, and referring to the early announcements of Dr. Robert Hooke, he goes on to state,

"According to Lavoisier, combustion can never take place but when oxygen is present. *Oxygen gas is considered by Lavoisier to be a compound of a gravitating base, with caloric and light.* When a combustible substance is exposed to the necessary temperature in oxygen gas, the latter is decomposed, the gravitating basis of the gas combines with the combustible, and the heat and light separate from the gas in the form of fire. . . . . . He attributed to oxygen gas a greater quantity of latent heat than to any other. A different explanation of the source of the supply of heat was soon, however, found necessary. . . . . .

Mr. Donovan then gives the reasons for this, and proceeds—

"A modified theory was then proposed. *Oxygen* GAS *consists of oxygen* (as the gravitating base was called) *combined with caloric.* Combustibles consist of an unknown base; combined with light, in combustion, a double decomposition takes place; the oxygen gas gives up its heat, and the combustible its light; the heat and light combine and form fire, while the oxygen and combustible base form the new product."† And so forth.

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* Heat, in Cab. Cyc. pp. 177, 178.

† Chemistry, in Cab. Cyc. pp. 350—352.

"It is also to be observed," says Mr. H. Reid, "that the WATER thus produced is to be regarded *as a compound of hydrogen and oxygen, not of hydrogen and oxygen gases.* These gases consist each of some unknown matter in union with heat, and, perhaps, light and electricity; and, as Dr. Henry observes, if we could divest them of these, they would probably appear in the solid or liquid form; but hydrogen and oxygen gases have never been condensed into the liquid form, no pressure that has been hitherto applied to them, and no degree of cold to which they have ever been subjected, being capable of producing this effect. We apply the term 'oxygen,' to that matter, for example, which, united with the iron in the gun-barrel, had assumed the solid form; that was, evidently, not oxygen *gas.* In like manner, the term hydrogen is applied to that matter which exists in union with oxygen in water, evidently not hydrogen *gas.* Every gas has, at least, two ingredients in its composition, namely, some gravitating matter, which may be called its base or principal part, and the subtile fluid caloric or heat, which, when present in sufficient quantity, causes this base to appear in the gaseous form. . . . . . It is considered, therefore, that oxygen and hydrogen gases consist of some unknown bodies, called oxygen and hydrogen, in union with a considerable quantity of heat. This heat is not apparent to our senses, does not make the oxygen and hydrogen feel warm, is not heat in the common meaning of the term: but it is, nevertheless, clear that they must contain it, or the principle which causes heat, for they produce it when they combine chemically, and produce a very large quantity of it. This heat was in them in a concealed or hidden state, but it has the effect of retaining them in the gaseous condition with great force, and, indeed, rendering it impossible for them to be condensed into liquids. . . . . . Oxygen and hydrogen gases, then, consist of oxygen and hydrogen united to a great quantity of heat."*

Having thus been made aware, in the most convincing manner, that gases are essentially composed of a gravitating base, in union with a subtile, self-expansive, imponderable fluid; we shall proceed to exhibit the fruitlessness of all attempts hitherto made to separate what were united by the sovereign fiat of the Omnipotent when it pleased Him, in the prosecution of the plan of creation, to will a union between the expansive principle and the bases of the elements of the atmos-

* Chemistry, by Hugo Reid, pp. 101, 102.

phere. "And God made the firmament." The remarkable and pointed testimony, which is unconsciously afforded by chemical research to the truth of this announcement of Scripture, is embodied in the *fifty-fifth* Theorem, wherein it is stated, "*That oxygen, nitrogen, and hydrogen gases have been severally submitted, by the first chemists of the age, to the enormous pressure of eight hundred atmospheres, without their having succeeded in reducing either of them to the liquid state; although many other gases have been liquidized by their vigorous and well-directed exertions.*" And again, in the *eighty-fifth* Theorem, it is asserted—"*That the elements of the atmosphere have never been either liquidized or rendered incandescent.*"

As this is rather a refreshing part of our labours, we shall dwell upon it as long as propriety will permit; bringing forward several witnesses, and interrogating them in detail.

"All substances," it is said in the *Connexion of the Sciences*, "may be compressed by a sufficient force, and are said to be more or less elastic, according to the facility with which they regain their bulk or volume when the pressure is removed, a property which depends upon the repulsive force of their particles. But the pressure may be so great as to bring the particles within the sphere of the cohesive force, and then an aeriform fluid may become a liquid, and a liquid a solid. Dr. Faraday has reduced some of the gases to a liquid state by very great compression; but although atmospheric air is capable of a diminution of volume, to which we do not know the limit, it has hitherto always retained its gaseous properties, and reserves its primitive volume the instant the pressure is removed."*

Dr. Thomson says—

"The atmosphere is composed of aerial fluids, chiefly oxygen and nitrogen, in the ratio of one volume of the former to four of the latter. Such is the result of numerous analyses. . . . . . The subject of the equable mixture of these gases is one of much difficulty, and as yet resting on probabilities. The atmosphere has hitherto resisted every effort to produce its liquifaction.

"Let us digress and examine the properties of these gases. They are elastic fluids, clear, colourless, devoid of smell and taste, but no further do they agree.

* Connexion of the Sciences, p. 119.

"*Oxygen* is heavier than air, its specific gravity being as 1.111 to 1.000. It is a supporter of combustion, and is the most powerful negative electric known; consequently always appears at the positive electrode. This gas has resisted the efforts of chemists to liquify it, though subjected to the pressure of 585 atmospheres, at the temperature of — 145° Fahrenheit. Without oxygen life could not be sustained. In it, unmixed with other gas, life flits away with greater rapidity than in common air. It is the most abundant of all elements. It is met with in every rock, rock-salt excepted; in water it forms 89 per cent., and it is an essential constituent in all organic bodies. It has been computed to constitute one-third of the weight of the whole globe.

"*Nitrogen* or *Azote* was first observed by Rutherford, of Edinburgh, in 1772. It is lighter than atmospheric air in the proportion of 0.9727 to 1.0. It neither supports combustion nor does it sustain life, though it performs a most important part in its economy. . . . . .

"These gases are not met with in nature *free*, with the single exception of the air volcanoes of Turbaco in South America, which give off nitrogen. To these ingredients of the atmosphere Orfila adds electricity, light, and caloric necessary for suspending the substances in the gaseous state."*

"The results of experimental enquiry," writes Dr. Lardner, in the Cabinet Cyclopedia, "justify us in assuming, as a universal law, that by the application of a sufficient quantity of heat all solids may be converted into liquids; and by the abstraction of a corresponding quantity of heat, all liquids may be converted into solids. We have likewise seen, that by the supply of heat in sufficient quantities, all liquids may be converted into the vaporous or gaseous form; and analogy would lead us to infer, that, by the due abstraction of heat, the bodies that exist in the gaseous form might be reduced to liquids. The practical results here, however, fall short of the anticipations to which analogy leads us. There is a numerous class of bodies existing in the gaseous form, among which atmospheric air may be mentioned as the most obvious, which no means hitherto known have converted into liquids. . . . . . If a permanent gas be submitted to severe mechanical compression, its temperature will be raised, and the heat which it contains may be more easily withdrawn from it, and imparted to freezing mixtures, or

* Introduction to Meteorology, 1849, pp. 3, 6—9.

extracted by any of the usual means of exposing it to extremely low temperatures. By continually carrying on the process of compression, additional quantities of heat may be developed and withdrawn, so that at length we may succeed in reducing the quantity of heat contained in the gas to that sum of latent and sensible heat, which seems the limit of the quantity necessary to maintain the elastic form. Any further reduction would be necessarily followed by condensation.

"Means similar to these have, accordingly, been applied and succeeded, in the hands of Dr. Faraday. . . . . . In this way, nine gases were condensed into the liquid form.

"Dr. Faraday attempted, without success, the condensation of various other gases by the same means. Oxygen, azote, and hydrogen have, it is said, been submitted to a pressure of eight hundred atmospheres, without passing into the liquid state."*

* Heat, in Cab. Cyc. pp. 177—179.

SECTION VII.

METEOROLOGICAL PHENOMENA RESULTING FROM THE LIGHT, AND FROM THE EARTH'S PROTOROTATION.

CHAPTER XXX.

Allusion to the concluding subject of the foregoing Chapter. Diffusion principle of Gases. Theorem and scientific evidences in favour of their expansiveness. Scriptural corroborations. The Atmosphere. Its aerial portion. Its aqueous or vaporous portion. The action of these two distinct bodies on one another, constituting the principal part of the machinery of the weather. Recapitulation of these points, and their application to elucidate the Dynamical Theory.

By the investigations which were entered into in the preceding section, we have been made aware, that the gaseous elements of the atmosphere consist of a base or radicle in union with the *expansive* principle, in so intimate a manner, that no means or power which the most scientific chemists have hitherto been enabled to bring to bear upon them, although a pressure equal to 800 atmospheres was applied, have been found sufficient to separate these associates. But we have yet to learn the more surprising fact, that, in a manner analogous to that in which each of these imperceptible particles may be supposed to be enveloped in a coating, or hollow sphere of expansion, their aggregate effect seems designed to produce a proportionally extended atmosphere, which surrounds the whole globe, with properties so peculiar as to indicate its almost abstraction from the otherwise universal law of gravity; for its elements expand by a law peculiar to themselves—termed "the *diffusion* principle"—into regions transcending the earth's surface by forty-five or fifty miles; although, strange to add, as a *collective* body this hollow sphere of aerial fluid possesses

considerable gravity, pressing upon the surface with a force, as already mentioned, of fifteen pounds for every square inch.

As the singular property of diffusion is that which more immediately interests us at present, by its illustrating in so striking a manner the truth of the inspired narrative, we shall attend to it exclusively. Meanwhile, as this peculiar principle has only lately been discovered, our notices respecting it will not be so full as we could otherwise have wished. The *eighty-seventh* Theorem has reference to it, and states, "*That, with respect to the oxygen and nitrogen gases of the air, although the expansive principle acts powerfully in repelling from each other the particles of the same gas, it does not act between those of different gases. That by the 'diffusion principle of gases,' when two are put together they will finally be arranged as if each occupied the whole space and the other was not present; the heavier being caused to ascend, and the lighter to descend. That this is the case with the gases of the atmosphere, and that there seems to exist a power acting upon permanent gases capable of counteracting, to a certain extent, the effects of the attraction of gravitation, and thereby forming an exception to what has hitherto been considered an universal law.*"

The following evidences will corroborate these truths:—

"Strange as it may appear," says Mr. Reid, "it is now the general opinion among chemists, that *the oxygen and nitrogen of the air are not in chemical union with each other, but that they are merely in a state of mechanical mixture.* . . . . . There are some reasons which might lead us to regard the oxygen and nitrogen of the air as existing in chemical union with each other. Oxygen and nitrogen, it is known, have a strong chemical attraction for each other, and are disposed to combine; the oxygen is heavier than the nitrogen, and if they are not in chemical union together, we should suppose that the oxygen would sink to the ground by itself, and the nitrogen float above it, like oil upon water; but this is not the case, for they are mixed in the same proportions at whatever distance from the ground, as Guy Lussac found in air which he collected at an elevation of nearly 22,000 feet, having ascended to that height in a balloon; also oxygen and nitrogen are present in the atmosphere exactly in the same proportions, estimated both by weight and by

measure, in which, from the laws of chemical combination, it is known they would be united, if it were a chemical union. But nevertheless, they are regarded as being merely mechanically mixed, not chemically combined; for, there is no change of form (to the solid or liquid state) as happens frequently when gases combine chemically; there is no diminution in bulk, another frequent effect of chemical union, the two gases occupying separately the same bulk as they do when forming air; generally, in effecting chemical combinations, something more is required than merely bringing the materials in contact with each other, as light, heat, or mechanical condensation, and it is well known, that gases do not combine readily on being merely mixed; but the proper proportions of oxygen and nitrogen, if merely mixed well with each other, form a gas having all the properties of air; the refractive power of the air is exactly what would be expected in a *mixture* of oxygen and nitrogen; there is no *alteration* of properties, merely a *weakening*, for the oxygen presents the same properties as in the uncombined state, only diminished in energy from the large quantity of nitrogen present; and lastly, there seems to be no affinity (at least a very weak one) binding the oxygen and nitrogen to each other, for the oxygen is abstracted with great ease by any substance which has an attraction for it, the nitrogen appearing to exert little or no force in retaining it. Water has the power of absorbing oxygen, though the attraction is not very great between them; yet even this weak affinity separates the oxygen from the nitrogen, for rain water contains a very large quantity of oxygen. Such are the leading arguments which may be adduced to show that the oxygen and nitrogen of the air are in a state of mechanical mixture, not chemically united.

"It has been supposed by some chemists (Berthollet and the late Dr. Murray), that although the affinity between the oxygen and the nitrogen, as they exist in the air, is not sufficient to bring them into close chemical union with each other, *it still acts and produces the effect of preserving their particles near each other, and thus counteracting the effect of the attraction of gravitation, which would tend to draw all the oxygen to the ground.* This explanation, it will be observed, has been given with the view of removing the difficulty, how the oxygen and nitrogen do not separate, the oxygen remaining undermost, if they are not chemically united. Some interesting experiments, however, by Dr. Dalton, of Manchester, showed that besides chemical attraction, there is another power in existence which would cause the two gases to remain mixed with each other,

and which would overcome the power of gravitation of the heavy one, which would tend to separate them. Dr. Dalton found, that two gases, however different in their specific gravities, and though they may have no chemical attraction for each other, mixed in whatever proportions in a close bottle, soon became equally diffused through one another. He made various experiments with different gases, amongst which were oxygen and nitrogen, and found, uniformly, the results to be, as he expressed in the following words: 'It appears to me as completely demonstrated as any physical principle, that whenever two or more such gases or vapours, as we have been describing, are put together into a limited or unlimited space, they will finally be arranged each as if it occupied the whole space, and the others were not present.' That is, each will be diffused or spread out through the whole space, not separating according to their respective specific gravities. This intimate intermixture of the two gases cannot be attributed to chemical attraction, for there is no chemical affinity subsisting between carbonic acid and hydrogen ; it must be dependent on some other power, which, acting between gases so different in density as carbonic acid and hydrogen, causing the heavy one to ascend and the light one to descend, will produce the same effects with the oxygen and the nitrogen in the air. It is now generally considered, that it is in obedience to this law, that the oxygen and the nitrogen are mixed in air in the same proportion everywhere. Dr. Dalton supposes, that though the repulsive principle acts powerfully in repelling from each other the particles of the same gas, it does not act between those of different gases; that, therefore, a gas, by the elasticity of its particles expands into any space to which it may have access, completely disregarding any other gas which may be in that space, while the gas previously there acts in the same way, and they thus become mutually diffused through each other.

"Mr. Graham, of Glasgow, found that this expansive tendency in each gas is so great, that the intermixture takes place even when the the two gases are separated by some substance of a porous nature, as plaster of Paris, bladder, cork, or stoneware. It has been named 'The Diffusion of Gases,' and as it is an extremely curious and interesting subject, throwing light on many natural phenomena, and bringing to view a power formerly quite unknown, and capable of producing effects, which, from our previous knowledge of the laws of nature, we would have been apt to pronounce as impossible, we shall

make a few extracts from Mr. Graham's paper, which will convey some idea of this new mine which has lately been opened up in chemical philosophy.

"On repeating Doebereiner's experiment, and varying the circumstances, it appeared that hydrogen never escaped outwards by the fissure without a certain portion of air returning inwards.

"This is the peculiar phenomenon pointed out by Mr. Graham :— *An interchange of the two gases (the hydrogen within the jar, and the air without) taking place through the fissure. . . . . . If the gases are of unequal density, there is a consequent accumulation on the side of the heavy gas, and loss on the side of the light one.* In the case of air, for instance, on the one side of the screen, 'the porous substance,' and hydrogon gas on the other, a process of exchanging one measure of the air for 3.7947 measures of hydrogen, through the apertures is commenced, and continues till the gases on both sides of the screen are in a state of uniform mixture. . . . . . When a diffusion-tube, six inches in length, was filled with hydrogen over mercury, the diffusion, or exchange of air for hydrogen, instantly commenced, through the minute pores of the stucco, and proceeded with so much force and rapidity, that within three minutes the mercury attained a height in the receiver of upwards of two inches above its level in the trough. . . . . . The ascent of the water in the tube, when hydrogen is diffused, forms a striking experiment. In a diffusion-tube 14 inches long, the water rises six or eight inches in as many minutes. The column of water attains in a short time its maximum height, at which, however, it is never long sustained; for, as in Doebereiner's experiment, air is all along entering mechanically from the pressure of the atmosphere through the parts by which the interior gas escapes; and after the diffusion is over, the water subsides, in the course of several hours, to the general level.

"Such are the facts brought to light by Mr. Graham's experiments, and although our knowledge of the diffusion principle may be considered as yet in its infancy, they evince the existence of a power acting upon gases, and capable of counteracting, to a certain extent, the effects of the attraction of gravitation, forming an exception to what was formerly considered a universal law."

In conclusion, Mr. Reid states—

"Our knowledge of the diffusion principle may be considered as yet merely incipient, but the discovery is one of the most interesting

that has been made for many years; and much may be expected from the progressive development of this singular law."*

"The aqueous particles," says Dr. Ure, "are not suspended in the atmosphere by any power analogous to that of chemical solution. There is merely a mechanical mixture of particles in juxta-position, a state which most probably represents the mixture of oxygen, azote, and carbonic acid in the permanent atmosphere."

Mr. Daniel has the following just remarks on this curious subject—

"The constancy of the proportions, in which these gases are found to be combined in every situation, notwithstanding perpetual causes of disturbance, is the never-failing theme of wonder. If we suppose a consumption of the oxygen to take place, by the decomposition of the oxygen and carbonic acid added, as in the process of combustion, at any given spot, in what way is chemical affinity to act, so as to restore the uniformity of the compound? No new evolution of oxygen takes place, and it cannot be supplied by the contiguous portions, for we can never suppose the affinity of azote for oxygen to be satisfied, by the decomposition of an adjoining mass of azote and oxygen, held together by the same affinity. But if the oxygen and azote be two distinct elastic atmospheres, as Mr. Dalton originally suggested, mutually permeating one another's interstices, the particles of each pressing only upon their fellows, and offering slight obstacles to the motions of the other sort; then a partial consumption of oxygen would be instantly supplied by a rush of the elastic fluid towards the spot where the equality of the pressure had been disturbed. In fact, no sooner does a particle of oxygen quit the azote and enter into a new combination, than the rows of particles by which it was pressed all around, speedily supply its place. The same reasoning may be applied to carbonic acid, so profusely generated in combustion and respiration; for, if not rapidly dispersed, a city would be uninhabitable in still weather."†

Dr. Thomson says—

"The proportion of oxygen and nitrogen in the atmosphere are the same on the tops of mountains and in the most sheltered valleys. . . . . .

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* Popular Chemistry, pp. 76—81.

† Ure, pp. 65, 66.

"From every recorded analysis of air," he continues, "*Uniformity has*" invariably "*resulted*. . . . . The equable mixture of these gases, though of dissimilar specific gravities, has been ascribed to the principle of resistance of the particles of the same gaseous fluid. Thus the molecules of oxygen are supposed to repel those of the same gas, while those of nitrogen repel, in like manner, the molecules of nitrogen. In other words, they mutually mingle as if no other gas was present. Other explanations have been offered by celebrated individuals, so that the subject is one of much difficulty, and as yet rests on probabilities. . . . .

"The weight of a column of air upward to the utmost limit of the atmosphere, incumbent on a determinate horizontal surface, is exactly the weight of the column of mercury in the tube of the barometer, providing the calibre of the instrument is equal to the given surface; and thus the weight of the entire atmosphere is equal to a sea of mercury covering the superficies of our globe to the depth of about thirty inches.

"Let us suppose with some, that atmospheric air is a *chemical* compound, an idea argued against by the late Dr. Dalton; or grant with that great philosopher, that the gases are merely *mechanically blended*, we cannot too much admire the wisdom of the Creator in adjusting the proportions so exactly for the comfort and preservation of his creatures. We have stated, that *four* volumes of nitrogen, and one volume of oxygen form atmospheric air, or to reduce the ratio to the following standard, two volumes of nitrogen and half a volume of oxygen compose the air we breathe. *Two* volumes of nitrogen and *one* volume of oxygen form nitrous oxide, a fluid which would be fatal if breathed for any length of time. *Two* volumes of nitrogen and *two* volumes of oxygen form nitric oxide, a gas which cannot be respired. *Two* volumes of nitrogen and *three* volumes of oxygen form hyponitrous acid, which exists only in combination with a base. *Two* volumes of nitrogen and *four* volumes of oxygen form the nitrous acid already mentioned. *Two* volumes of nitrogen and *five* volumes of oxygen compose nitric acid or aquafortis, one of the most corrosive and deadly poisons. Thus of *all* the combinations of these two gases, atmospheric air is the *only* one fit for sustaining life! How easily would the destruction of the globe be effected, were the Creator to change the proportions of these fluids."*

* Introduction to Meteorology, pp. 6, 24, 13.

The delight which we feel in accumulating, as it were, every possible proof in favour of the wisdom and beneficence of the Deity, induces us to give, with much pleasure, the following additional testimony to these attributes, manifested by the formation of the atmosphere:—

"In viewing the atmosphere," says Dr. Ure, "as consisting of oxygen and azote, we cannot help remarking the delicate equilibrium of chemical proportions on which the well-being of organic life, and even the whole aspect of nature depend.

"Were the proportion of oxygen or vital air diminished, breathing would be laborious, every warm-blooded animal would become asthmatic, and coal would not cheer the domestic hearth. On the other hand, were the proportion of the vital ingredient doubled, that is, instead of one of it to four of azote, as at present, were there two to four, the temperate breath of heaven might suddenly change into an atmosphere of intoxicating gas; for these are the chemical proportions and sole constituents of this curious air. Were the bulk of oxygen quadrupled, so that its quantity should equal that of azote, a most noxious air called nitrous gas (dentoxide of azote) might result; a gas which, with an additional charge of oxygen would condense into an ocean of aqua fortis, or nitric acid. A slight modification of chemical affinity, would convert even our existing atmosphere into the most corrosive of liquids; a result which the Hon. Mr. Cavendish many years ago produced, by merely transmitting electric explosions through a small portion of common air. But science shows that the chemical equilibrium of the atmospheric elements is fixed by the same beneficent wisdom which confines the turbulent ocean, by an apparently slender barrier of sand."*

We consider the establishment of these points, and especially that of the principle "of the diffusion of gases," by which they are caused to expand throughout the whole extent of the aerial ocean, as some of the most convincing proofs of the truth, and the unchangeableness of that Word, which, though heaven and earth pass away, will not pass away. Most sincerely do we compassionate that mind, if any such there be, which can turn away with cold indifference from the contemplation of these convincing corroborations of the Divine Record;

* Ure, pp. 53, 54.

and not rather gratefully render thanks to God for having permitted, that the wonders both of "the heaven" and of "the earth" which "he created in the beginning," should be brought to light, unconsciously though it may be, in order to vindicate the truth of his communications. For, it is a source of unspeakable satisfaction to those who believe, to be enabled to bring the truths of philosophy to bear directly in favour of that book, to whose bright and cheering light they look for guidance amidst the storms, the perils, and the uncertainties of life.

It is remarkable, likewise, to observe, how evidently that great Being, whose spirit breathes throughout the sacred volume, seems to have been desirous to indicate, as it were with his finger, the way to those discoveries long, long ago; for they are repeated, at intervals, throughout the whole course of the divine revelation to man, with a clearness only equalled by his wayward reluctance to appreciate them. In proof of this we shall bring forward a few from amongst the numerous passages of Scripture, which might be quoted, to show, that the expansive principle, now termed the "Diffusion of Gases," is as clearly indicated, as if volumes, detailing the results of experimental philosophy, had been written on the subject.

"Hearken unto this, O Job: stand still and consider the wondrous works of God. Dost thou know when God disposed them, and caused the light of his cloud to shine? Dost thou know the balancings of the clouds, the wondrous works of him which is perfect in knowledge? Hast thou with him spread out the sky, which is strong, and as a molten looking-glass?"*

"Bless the Lord, O my soul. O Lord my God, thou art very great; thou art clothed with honour and majesty: Who coverest thyself with light as with a garment; who stretchest out the heavens like a curtain."†

"Have ye not known? have ye not heard? hath it not been told you from the beginning? . . . . . It is he that sitteth upon the circle of the earth; . . . . . that stretcheth out the heavens as a curtain, and spreadeth them out as a tent to dwell in."‡

"Thus saith the Lord, thy Redeemer, and he that formed thee,

* Job xxxvii. 14—18. † Psalm civ. 1, 2. ‡ Isaiah xl. 21, 22.

I *am* the Lord that maketh all things; that stretcheth forth the heavens alone; that spreadeth abroad the earth by myself."*

"I have made the earth, and created man upon it: I, *even* my hands, have stretched out the heavens, and all their host have I commanded."†

"I, *even* I, *am* he that comforteth you: who art thou, that thou shouldst be afraid of a man that shall die, and of the son of man which shall be made as grass? And forgettest the Lord thy maker, that hath stretched forth the heavens, and laid the foundations of the earth."‡

"But the Lord is the true God, he is the living God, and an everlasting King: at his wrath the earth shall tremble, and the nations shall not be able to abide his indignation. Thus shall ye say unto them, The Gods that have not made the heavens and the earth, *even* they shall perish from the earth, and from under these heavens. He hath made the earth by his power, he hath established the world by his wisdom. When he uttereth his voice, there is a multitude of waters in the heavens, and he causeth the vapours to ascend from the ends of the earth; he maketh lightnings with rain, and bringeth forth the wind out of his treasures."§

These sublime passages, and innumerable others to the same effect which might be quoted, must convince every impartial person that our ignorance cannot be chargeable to the Almighty; for he, by the mouth of his inspired servants, has from time to time, and from age to age, repeatedly indicated these truths to us in language as plain as could be either spoken or written; indeed Jehovah informs us, by the mouth of Isaiah, that he declared "all things from the beginning, lest we should say, 'Behold, I knew them;'"‖ that "He, even He, stretched forth the heavens as a curtain," that He "spread them out as a garment." Indeed, no announcement in Scripture, having relation to material objects, is more consistent than this; for, wherever there is occasion to mention the atmosphere, the language uniformly made use of *indicates the expansion, or diffusion of the elements which compose it.* And, surely there must be something very far wrong, when the evidence afforded by a few experiments, made in glass

* Isaiah xliv. 24. † Ibid, xlv. 12. ‡ Ibid, li. 12, 13.
§ Jeremiah, x. 10—13, and li. 15, 16. ‖ Isaiah xlviii. 3—8.

retorts and earthen tubes, in a chemist's laboratory, commands more respect, and produces more conviction, than the repeated announcements of Him who made them all; and who stretched forth these very heavens by his wondrous wisdom and his power; and spread out the earth, aye, and even formed the very earth-worms—who dare to give more credit to their own molten images than to the true God! Oh! for such a spirit of self conviction, humiliation, and repentance, as might, if possible, still avert the awful doom which seems to have been predicted even upon us, when the prophet adds, in the verses which immediately follow those last quoted: "Every man is brutish in his knowledge; every founder is confounded by the graven image; for his molten image is falsehood, and there is no breath in them. They are vanity, and the work of errors; in the time of their visitation they shall perish."* And let us keep it ever in mind, that the reconciliation of these two branches confirms the great and important announcement, that "Heaven and earth may pass away, but the word of the Lord shall not pass away!"

But to return to the scientific investigation of the subject in which we are engaged.

Whoever has paid any attention to what has been written on meteorology, must be aware, that the atmosphere comprehends two distinct bodies of colourless, inodorous, elastic fluids; the one of Air, the other of Vapour; the former composing, by far, its greatest volume and most important part, whose movements and changes give a tone to the whole; while the watery vapour, though comparatively insignificant in volume, or weight, is yet absolutely essential to the well-being and existence of the animal and vegetable kingdoms of nature. And, whoever may have studied the corresponding part of Scripture with attention, will perceive that, analogous thereto, there is a twofold division in its announcements; the one having reference to the aerial part of the firmament—"Let there be a firmament in the midst of the waters;" and the other to the vaporous associate of the atmosphere—"And let *it* divide the waters from the waters." The truth of these

* Jeremiah, x. 14—16.

assertions will appear more evident if we attend to what is said in the following quotations:—

"We have seen," says Professor Whewell, "how many and how important are the offices discharged by the aqueous part of the atmosphere. The aqueous part is, however, a very small part only; it may vary, perhaps, from 1-100dths to nearly as much as 1-20th in weight of the whole aerial ocean. We have to offer some considerations with regard to the remainder of the mass.

"In the first place we may observe, that the aerial atmosphere is necessary as a vehicle for the aqueous vapour. Salutary as is the operation of this last element to the whole organized creation, it is a substance which would not have answered its purpose if it had been administered pure. It requires to be dilated and associated with dry air to make it serviceable. . . . . .

"Besides our atmosphere of aqueous vapour, we have another and far larger atmosphere of common air; a *permanently* elastic fluid, that is, one which is not condensed into a liquid form by pressure or cold, such as it is exposed to in the order of natural events. The pressure of the common air is about 29½ inches of mercury; that of the watery vapour, perhaps, half-an-inch. . . . . .

"Now this mass of dry air is by far the most dominant part of the atmosphere; and hence carries with it in its motions the thinner and smaller eddies of aqueous vapour. The latter fluid may be considered as permeating, and moving in the interstices of the former, as a spring of water flows through a sand rock."*

"Though the air we breathe," says another writer, "was formerly considered a simple substance, it is now known to be a compound. Its constituents are nitrogen, oxygen, and carbonic acid gases, and aqueous vapour, existing in a state, not of chemical combination, but of uniform intermixture with one another. . . . . . The relative proportion of the aqueous vapour contained in the atmosphere is extremely variable, and is regulated in a great measure by the temperature of the air. . . . . . It has been estimated, that in Great Britain during summer, the weight of water present in the atmosphere frequently amounts to $\frac{1}{60}$th of the whole; whereas in winter, it often does not exceed $\frac{1}{300}$th of the whole. In warm latitudes the weight of aqueous vapour contained in the atmosphere is fre-

* Bridgewater, Treatise, pp. 96—99.

quently double what it is, during summer, in Great Britain, while in the polar regions the proportion is extremely small. Dr. Dalton supposes, that the medium quantity of vapour held in solution by the atmosphere may amount to $\frac{1}{70}$th of its bulk."*

"Water," says Dr. Thomson, "*vaporises* when it passes into *steam* at 212° Fahrenheit, under ordinary pressure; below that temperature it *evaporates*, passing into the ambient air in insensible moisture, where it is retained till a diminution of temperature renders it apparent; for Dalton found that the amount and tension of vapour in the atmosphere is independent of the presence of the air, and wholly regulated by caloric. Hence arise clouds, mists, and other aqueous meteors, when the thermometer falls in a humid atmosphere. In the state of vapour, the moisture exists normally in the form of hollow vesicles, frequently mingled, however, with globules filled with water. . . . . . The diffusion of aqueous vapour in the atmosphere is what is meant by its humidity. . . . . . The question whether aqueous vapour is chemically combined or merely blended with the atmosphere has not been determined. Berzelius, Berthollet, Saussure, and Thomson support the former theory, Dalton, Henry, and the author, the latter."†

It is presumed, that what has now been said will be sufficient to explain the perfect harmony which prevails between the words of the inspired Record, and the experience of natural philosophy, as regards the formation of the elements of the aerial part of the firmament, and their permanently repulsive character, without any direct reference having been made to the completion of the work; for we trust soon to show, *that the Firmament or Atmosphere was not perfected, nor indeed could be, until the separation of the land from the water, on the third day of the* MOSAIC WEEK. And having gone so far through this intricate path in safety, by looking stedfastly to the divine Record, as a bright and friendly star to direct our more general course; while the lights of philosophy were called in to guide us through our earthly intricacies; we shall now turn to the remaining part of the same portion

* Principles of Meteorology, by Mr. Hutchinson, pp. 4—6.
† Dr. Thomson's Introduction to Meteorology, pp. 97, 100, 107.

of Scripture, and endeavour, by its guidance, to thread our way through whatever remains to be explored:—

"And God said, let there be a firmament in the midst of the waters; and let it divide the waters from the waters. And God made the firmament, and divided the waters which *were* under the firmament from the waters which *were* above the firmament; and it was so. And God called the firmament Heaven. And the evening and the morning were the second day."

We attach a different signification to these remarkable words from any which we have ever heard applied to them. We consider they have reference not only *to the relative positions in space* of the waters, thus commanded to be separated from each other, by the agency of the firmament; but we believe they likewise apply, as the means of effecting that separation, to *the relative degrees of expansive principle with which any portion of the water is for the time being combined.*

This view of the subject will be found to harmonize with those which have been adopted, as the result of experiments, by philosophers, who have been induced to ascribe similar inherent properties to what is termed the "*dew point,*" or "*constituent temperature for the maintenance of water in a state of vapour.*" For, supposing the *Firmament* of Scripture to be, as it assuredly is, *that constituent or Dew* point, and to be subject, itself, to variations according to altitude, temperature, and other concomitant circumstances (all indispensable for its perfection, as will presently be shown), then we can clearly comprehend how it is that the waters "*under the firmament*" refer to those which, at any particular place, are in a negative or inferior degree of combination with the expansive principle, or lower than "*their constituent temperature*" in relation to the atmosphere, at the same time and place; and, on that account, by condensing, *incline to descend;* while those again which are "*above* the firmament," have reference to such as are in excess of combination with the subtile element conferring expansion on them, and thereby they have become above their constituent temperature, and *are inclined to ascend.* Thus a division, varying in extent and degree, according to relative circumstances, is effected between these two portions of water,

by means of the atmosphere, which, by obeying different laws of heat, permits and enables the watery vapour to percolate through it with perfect freedom, whilst the aerial ocean serves as a carrier, from place to place, of the aqueous portion.

This signification of those words of Scripture, which presented itself to our mind years ago, seems to harmonize with the recent and scientific definition of the DEW *point*, as given by Dr. Thomson, who states that—

"The temperature denominated *dew-point*, is that which represents the point at which vapour is deposited upon an object colder than itself. . . . . . The difference between the dew-point and mean diurnal, mensual, or annual temperature is the *mean dryness* of the same respective periods. The *mean dew-point* is always below that of the mean temperature."

And again—

"Dew is the spontaneous appearance upon objects freely exposed to the atmosphere, of moisture which was invisible. . . . . . Dr. Wells is our chief authority on dew, and his theory, given in one of the most beautiful inductive essays in our language, is founded upon calorific radiation. . . . . . That it is the effect, not the cause, of the lowering of the temperature of the bodies bedewed."*

As the combination of the minute particles of water with the repulsive principle, is that which causes them to become watery vapour, and to ascend until they find their level in the atmosphere, they thereby naturally and spontaneously obey the law impressed upon them by the command here cited. For, leaving the great body of the water, which remains uncombined, they ascend and are divided from it *both in temperature and in space*, as long as they continue in a positive state, or "above the firmament;" while they descend to rejoin their parent source, as soon as, from causes whose explanation will presently be attempted, they fall *below their* constituent temperature at the particular point of the atmosphere where they happen to be. And thus, as the one state directly induces the other, the harmony prevailing between them, as cause and effect, shows that the interpretation given of this

* Introduction to Meteorology, pp. 105, 108.

passage of Scripture is correct. It likewise reveals, in the clearest manifestation, the never-failing integrity of the words of the inspired historian; which viewed in whatever light they may be, or whatever application may be made of them to natural phenomena, are found ever to be true.

This interpretation is, besides, the only one which can be adopted of these words, in strict consistency with the vicissitudes of the weather, and the refreshing phenomena of rain or dew. For, impressed with the belief, that every command of the first chapter of Genesis conferred an unalterable feature on nature; in other words, *that they constituted nature itself*, had not some modifying influence of this kind been provided, when the firmament was formed, some regulating power, whereby the changes of the one would induce a corresponding change, producing different effects on the other, then the "water" once divided by "the firmament," must have remained unalterably so, until it pleased the Omnipotent, by an act of equal sovereignty, to release it; and in like manner, a similar *direct* interposition of Providence would have been required, before the earth could have been, on any occasion, refreshed with the dews and the rains of heaven.

But by the interpretation just given of these words, the undeniable principle, of the permanency of the commands recorded in Genesis, has been saved, and shown to be in harmony with all the other conditions of the case; and a simple and adequate provision, so simple and natural, indeed, as to make us almost forget that the Lord doeth it all, is recognized as having been made by these comprehensive words; for those bountiful and merciful vicissitudes of weather, whereby, at one time, the parched earth is refreshed by moisture, which descends, "as soft as showers upon the mown grass;" and, at other seasons, for a due distribution of heat and warmth, by which vegetation is caused to germinate and is fostered until the terraine surface becomes clothed as with a mantle of verdure. Let us, however, endeavour to prove, by the announcements of philosophy, that the meaning we have applied to these words is in accordance with the scientific facts of the case.

In doing this, we shall, first of all, recapitulate the *ninety-third* Theorem—"*That the watery vapour of the atmosphere is*

due to the influence of HEAT; *which, infusing the repulsive principle into the waters of the seas, rivers, and lakes, causes them to ascend in an aeriform state.*

"*That the ocean undergoes a continual process of evaporation, and dismisses into the atmosphere a quantity of pure water, proportionate to its extent of surface, to the temperature of the air, and to its state of saturation.*

"*That whenever the temperature of the air is reduced below the limit at which the suspended vapour is maintained in a state of saturation, condensation takes place, and rain or aqueous clouds are produced.*

"*And that by these alternate processes the terraine surface of our globe is supplied with fresh moisture and with water necessary to sustain the organization, and to maintain the functions of the animal and vegetable kingdoms.*"

Without giving any of the details of a theorem, so complete in itself as almost to be sufficient explanation of the matter it involves, we shall pass on to the recapitulation of the remaining theorems relating to this particular subject; and, in conclusion, bring forward evidences common to them all.

The *ninety-fifth* Theorem states, in part—"*That the* VAPORIZATION *of a* FLUID *is accelerated by the increase of its temperature, and more so when heat is applied to a surface free from external pressure; in a vacuum vaporization is almost instantaneous. The agitation of the surface likewise increases the effect. That, in general, the rate of evaporation from the surface of the water, in all states of the atmosphere, will be proportioned to the tension of vapour which would saturate the atmosphere, diminished by the tension of the vapour actually in the atmosphere.*"

And, in continuation of the same subject, it is given in the *ninety-fourth* Theorem—"*That the following seem to be the most obvious principles, whose combinations and mutual action on each other govern and modify the meteorological state of the atmosphere, namely:—The existence of a constituent temperature for the maintenance of water in a state of vapour. The opposite tendencies of air from the colder to the warmer parts; and of vapour from the warmer to the colder parts of the atmosphere and terraqueous surface. The different rates at*

which the temperature and tension of air and of vapour decrease as they ascend from the surface of the earth or sea. The different capacities for heat of those two component parts of the earth's surface. And, lastly, the unequal distribution of the electric fluid in the nephalic masses of the atmosphere, and its tendency to a state of equilibrium."

The evidences common to these several propositions, which we give in continuation, will tend, while they illustrate what has been said, to prepare the mind for what is to form the subject of the next section, when the use, made by the Creator, of the new formed atmosphere, in separating the water from "the dry land" by evaporation, will be considered, and its explanation attempted. Some sentences of these extracts have been quoted already, when illustrating other positions, but this, as it is almost unavoidable, we trust will be overlooked; a passage written without reference to our subject, may contain a confirmation of two or three different parts of the same argument:—

"Besides our atmosphere of aqueous vapour," says Professor Whewell, "we have another and far larger atmosphere of common air, a *permanently elastic fluid*, that is, one which is not condensed into a liquid form by pressure or cold, such as it is exposed to in the order of natural events. The pressure of the dry air is about 29½ inches of mercury; that of the watery vapour, perhaps half-an-inch. Now, if we had the earth quite dry, and covered with an atmosphere of dry air, we can trace in a great measure what would be the results, supposing still the equatorial zone to be hot, and the temperature of the surface to decrease perpetually as we advance into higher latitudes. The air at the equator would be modified by the heat, and would be perpetually displaced below by the denser portions which belonged to cooler latitudes. We should have a current of air from the equator to the poles in the higher regions of the atmosphere, and at the surface a returning current, setting towards the equator, to fill up the void so created. . . . . .

"Now, a mass of dry air, of such a character as this, is by far the dominant power of our atmosphere: and hence carries with it in its motions the thinner and smaller eddies of aqueous vapour; the latter fluid may be considered as permeating and moving in the interstices of the former, as a spring of water flows through a sand rock.

"The lower current of air is, as has been said, directed towards the equator, and hence it resists the motion of the steam, the tendency of which is in the opposite direction, and prevents or much retards that continual flow of hot vapour into colder regions; by which a constant precipitation would take place in the latter situations.

" . . . . . Thus in the lower part of the atmosphere, there are tendencies to a current of air in one direction, and a current of vapour in the opposite; and those tendencies exist in the average weather of places situated at a moderate distance from the equator. The air tends from the colder to the warmer parts, the vapour from the warmer to the colder.

"The various distribution of land and sea, and many other causes, make these currents far from simple. But in general the air current predominates, and keeps the skies clear and the moisture dissolved. Occasional and irregular occurrences disturb this predominance; the moisture is then precipitated, the skies are clouded, and the clouds may descend in copious rains.

"These alternations of fair weather and showers appear to be much more favourable to vegetable and animal life than any uniform course of weather could have been. To produce this variety, we have two antagonist forces, by the struggle of which such changes occur. Steam and air, two transparent and elastic fluids, expansible by heat, are, in many respects and properties, very like each other. Yet, the same heat similarly applied to the globe, produces at the surface currents of those fluids tending in opposite directions. And these currents mix and balance, conspire and interfere, so that our trees and fields have alternately water and sunshine, our fruits and grain are successively developed and matured. . . . . .

"But we have not yet done with the machinery of the weather. In ascending from the earth's surface through the atmosphere, we find a remarkable difference in the heat and in the pressure of the air. It becomes much colder and much lighter; men's feelings tell them this; and the thermometer and barometer confirm these indications.

"In both the simple atmospheres of which we have spoken, the one of air, and the one of steam, the property we have mentioned must exist. In each of them, both the temperature and the tension would diminish in ascending. But they would diminish at very different rates. The temperature, for instance, would decrease much more rapidly for the same height in dry air than in steam. If we begin with a temperature of 80° at the surface, on ascending 5,000

feet the steam is still 76½°, the air is only 64½°; at 10,000 feet the steam is 73°, the air 48½°; at 15,000 feet, the steam is at 70°, the air has fallen below the freezing point to 31½ degrees. Hence these two atmospheres cannot exist together without modifying one another; one must heat or cool the other, so that the coincident parts may be of the same temperature. This accordingly does take place, and this effect influences, very greatly, the constitution of the atmosphere. For the most part, the steam is compelled to accommodate itself to the temperature of the air, the latter being of much the greater bulk. But if the upper part of the aqueous vapour be cooled down to the temperature of the air, they will not, by any means, exert on the lower parts of the same vapour so great a pressure as the gaseous form of these could bear. Hence, there will be a deficiency of moisture in the lower part of the atmosphere, and if water exist there, it will rise by evaporation, the surface feeling an insufficient tension; and there will thus be a fresh supply of vapour upwards. As, however, the upper regions already contain as much as their temperature will support in the state of gas, a precipitation will now take place, and the fluid thus formed will descend till it arrives in a lower region, where the tension and temperature are again adapted to its evaporation.

"Thus, we can have no equilibrium in such an atmosphere, but a perpetual circulation of vapour between its upper and lower parts. The currents of air which move about in different directions at different altitudes, will be differently charged with moisture, and as they touch and mingle, lines of cloud are formed, which grow and join, and are spread out in floors, or rolled together in piles. These, again, by an additional accession of humidity, are formed into drops, and descend in showers into the lower regions, and if not evaporated in their fall, reach the surface of the earth. Here, then, we have another remarkable exhibition of two laws, in two nearly similar gaseous fluids, producing effects alike in kind, but different in degree, and by the *play* of their difference giving rise to a new set of results, peculiar in their nature and beneficial in their tendency. . . . .

"From what has been said we may see, in a general way, both the causes and the effects of *winds*. They arise from any disturbance by temperature, motion, pressure, &c., of the equilibrium of the atmosphere, and are the efforts of nature to restore the balance. Their office in the economy of nature is to carry heat and moisture from one tract to another, and they are the great agents in the distribution of temperature and the changes of the weather. Other purposes

might easily be ascribed to them in the business of the vegetable and animal kingdoms, and in the arts of human life, of which we shall not here treat. That character in which we now consider them, that of the machinery of atmospheric changes, and thus, immediately or remotely, the instruments of atmospheric influences, cannot well be refused them by any person."*

"Meteorology," observes Mr. Hutchinson, "is that department of physical science which treats of atmospheric phenomena. . . . . . Several of these are so mutually dependent upon each other, that with a view to explain their causes it is difficult to decide upon what arrangement ought to be adopted. For instance, variations of temperature on different parts of the earth's surface disturb the atmospheric equilibrium, and give rise to aerial currents; while, on the other hand, aerial currents, according as their direction is from a cold to a warm climate, produce important alterations in the temperature of the incumbent atmosphere. Again, variations in the atmospheric temperature are principally instrumental in the formation and dissolution of clouds; while, on the other hand, the existence of clouds reduces the temperature of the subjacent atmosphere during the day of summer, and augments it during night and winter." . . . . .

"I am disposed to think," says he, at another part, "that the increased capacity of air for heat, according as the superior aerial compression diminishes, is either the true cause, or rather a constant and necessary concomitant of the true cause of the mean rate of decreasement of temperature, upon ascending perpendicularly from the sea."

"The parent source," he continues, "from whence the atmosphere, when undersaturated, derives a supply of aqueous vapour, is the ocean. The process by which it is supplied is called evaporation, ... and, as a considerable proportion of the moisture which is precipitated upon the land is returned to the ocean by means of rivers, it is obvious that the land would soon become dried up, were it not supplied with humidity from the ocean, through the agency of evaporation and atmospheric currents." . . . . .

"Clouds," says Dr. Prout, "are the great means by which water is transported from seas and oceans to be deposited far inland, where water otherwise would never reach. They, also, greatly mitigate the extremes of temperature. By day they shield vegetation from

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* Bridgewater Treatise, pp. 98—106.

the scorching influence of the solar heat; by night, the earth, wrapt in its mantle of clouds, is enabled to retain that heat which would otherwise radiate into space; and is thus protected from the opposite influence of the nocturnal cold. . . . . . And whether we contemplate them with respect to their form, their colour, their numerous modifications, or, more than all, their incessant state of change; clouds prove a source of never-failing interest, and may be classed among the most beautiful objects in nature." . . . . .

And lastly, from this writer—

"When treating of the formation of the *Fall-cloud* we explained the causes and principles which, according to the experiments of Dr. Wells, determine the formation of dew. . . . . . This consists of moisture precipitated from the aerial strata nearest the ground, in consequence of coldness (induced by radiation of caloric from the earth's surface during calm, clear nights) being communicated to those strata in sufficient intensity to produce over saturation. Hence, agreeably to the beneficent designs of Providence, by which scarcity produces provident economy, and by which all phenomena are adapted upon the wisest principles to serve useful purposes, frugality in its distribution is observed to be proportionate to the smallness of its quantity; and, according to Dr. Wells, 'appears chiefly where most wanted, on herbage and low plants, avoiding in great measure rocks, bare earth, and considerable masses of water. Its production, too, by another wise arrangement, tends to prevent the injury that might arise from its own cause, since the precipitation of water upon the tender parts of plants must lessen the cold in them which occasions it.' "*

"As the capacity of air for moisture varies with its temperature," observes Mr. Graham, " the attention of philosophers has been directed to ascertain the relative ratio of variation. . . . . . Judging from the experiments which have been made, it appears, that while the temperature of air increases in arithmetical progression, its capacity for holding moisture in invisible solution increases in geometrical progression, or very nearly so. And in every increment of temperature amounting to about 23°.4 of Fahrenheit's scale, the capacity of air for moisture is doubled. Thus, if the capacity of air for moisture be denoted 1 at the temperature of zero, it will be

* Principles of Meteorology, by G. Hutchinson, Intro. pp. 117, 177, 222.

2, or double the zero capacity, at the temperature of 23.4; 4, or the quadruple, at 46.8; eight times the zero capacity at the temperature of 70°.2; and sixteen times the zero capacity at the temperature of 93°.6, &c.

"It has been ascertained, that the temperature of the atmosphere, in all latitudes, diminishes on ascending perpendicularly from the level of the sea; but the rate of diminution, as determined by different observers, and even by the same observer, at different times and places, varies greatly. . . . . .

"When the humidity or the dryness of the atmosphere is mentioned, reference is made, not to the absolute amount of moisture in the air, but to the amount in relation to its capacity. The more under-saturated the atmosphere is, the drier it is said to be, and the stronger is its influence in promoting evaporation from moist surfaces. On the contrary, the nearer it approaches to saturation, the more humid it is and the less its influence in promoting evaporation. . . . . The precipitation of moisture into the visible form of mist or clouds, may arise either from the reduction in the temperature of the atmosphere, or from a reduction in reference to its capacity.

"Dr. Thomson says, 'though there is no doubt that clouds consist of a congeries of vesicles, we have no conception of the way in which these vesicles are formed. . . . . . The formation of clouds, indeed, seems to be connected with electricity, though in what way the vesicular form is induced by electricity, we have no conception. The vesicles seem to be all charged with the same kind of electricity. This causes them to repel each other, and of course prevents them from uniting into drops of rain.' . . . . .

"And again he says, 'air and all gases are non-conductors; but vapour and clouds, which are composed of it, are conductors. Clouds consist of small hollow bladders of vapour, charged each with the same kind of electricity. It is this electric charge which prevents the vesicles from uniting together, and falling down in the form of rain. Even the vesicular form which the vapour assumes, is probably owing to the particles being charged with electricity. The mutual repulsion of the electric particles may be considered sufficient (since they are prevented from leaving the vesicle by the action of the surrounding air, and of the surrounding vesicles), to give the vapour the vesicular form."*

* Principles of Meteorology, by G. Hutchinson, pp. 9, 17, 153. Dr. Thomson on Heat and Electricity, pp. 274, 440. Also Dr. Wells on Dew.

"The experiments of the illustrious Dalton and Guy Lusac," says the author of the Philosophy of Storms, "have shown, that when the dew-point is 80° Fahrenheit, and the barometer 30 inches, the quantity of vapour in atmospheric air is $\frac{1}{48}$th of the whole weight and $\frac{1}{30}$th of the whole bulk; when the dew-point is 71° the quantity is one-fourth less; and when that constitutional point is 59° the quantity of vapour is one-half as much as when it is at 80°, while at 39° the quantity would be reduced to one quarter.*

These evidences demonstrate to a certainty, that the view adopted of the separation recorded in Scripture of the waters *under* the firmament, from the waters *above* the firmament, imply, that the latter were abstracted from the dominion of gravity, by combination with the expansive principle, and thereby caused to ascend until they found their level *upwards;* while those which were *not* thus combined, but remained in their former state, were so far under the dominion of the gravitating power, that they sought—as waters do in their natural state—their level *downwards*.

This instance we offer as a most satisfactory confirmation of the position formerly assumed, namely, that the division of the light from the darkness, *consisted in the* DIVERGENCY *of the tendency of their influences in space:* the former propending from the centre towards the circumference; the latter from the circumference towards the centre. For, as these two are the only instances in this part of Scripture, where the term *divide* occurs, they seem mutually to shed an explanatory light on each other. And it is worthy of remark, that we find the same principle, *the* LIGHT or EXPANSION, employed to effect this separation, evidently without any new character having been impressed upon it for that purpose; but taken up and made use of as an agent already capable of cenferring expansion or repulsion. "Let there be a firmament (or expansion) in the midst of the waters, and let it (*i. e.* the expansion) divide the waters from the waters." And when we further reflect, that the expansive principle employed on this occasion *must*

* Philosophy of Storms, p. 1.

have been the new formed light; for the opposite principle—attraction—had existed for ages upon the water—"Darkness was upon the face of the deep"—*without having produced an atmosphere or firmament,* it cannot fail to afford an additional testimony to every candid mind, *that the division of the light from the darkness,* on the first day of the Mosaic week, *was the means of conferring an expansive principle upon the light;* and, that the new principle, thus formed, was made use of as the agent in effecting the division of "the waters which were *under* the firmament from the waters which were *above* the firmament."

This conclusion, it is apprehended, is perfectly correct; yet least any doubt should still harbour in the mind from the suspicion, that when the firmament or atmosphere was formed, the Creator introduced some additional *material or ponderable substance* into the universe; we mean, *added new matter* to the earth, we take occasion to show by the simple application of one of the most accredited laws of mechanics, motion and momentum, that no such addition was made. It is stated in the two concluding paragraphs forming the *fifth* rule of the *seventy-third* Theorem, "that weights, *which are as one to two,* revolving at equal distances with the same velocity, will have their centrifugal forces as one to two; the centrifugal force increasing as the mass of the moving body increases," and consequent on this invariable law of mechanics, had any addition been made to the *matter,* or, in other words, to the *weight* of the world, by the formation of the atmosphere, the angular momentum of the earth's rotation would have increased in a corresponding ratio; and so would also its centrifugal impetus around the sun; and, thereby, both its diurnal rotation and its orbital motion in space, would have been acted upon and disturbed. Nor is this all. By the further application of the same laws—those of mechanics—we can determine the special nature of that which was added to the material radicle or base of the atmosphere, to give it expansion, and condescend upon the precise period, almost to an hour, when this was done; for we find by the *second* rule of the *same* Theorem, "that weights revolving with the same angular velocity, *at distances*

from the centre in the proportion of one to two, have their centrifugal force in the same proportion." By which we are enabled to conclude, that *whatever of* MATTER *is embodied in the atmosphere* was raised at once to the height *above* the surface, or distance *from* the centre, by the centrifugal impetus impressed on the earth by its first rotation round its axis, and by the impartation of the expansive principle, when such *matter* was driven off from the centre to that distance which the figure of rotation demanded; and that whatever was added thereto, to constitute the firmament, or atmosphere, on the second day of the Mosaic week, did not possess *the slightest appreciable gravity*. The only elements in nature known to be so circumstanced are light, heat, and electricity; therefore some one of those kinds of the expansive principle, must have been that which was applied to form the buoyant constituent of the atmosphere; and which thoroughly agrees not only with what is announced by the inspired historian, when he asserts that "God said, Let there be a firmament in the midst of the waters, and Let it divide the waters from the waters," but is also in strict accordance with the latest conclusions which have been come to, on the subject, by philosophical writers.

"The Meteorology of the present epoch," says Dr. Thomson, "is very different from that of Aristotle and his pupil Theophrastus, or even that of the early years of the present century. The unwearied labours of a goodly host distributed over the globe, have been already amply rewarded, and we look forward with no small expectation to 'coming events,' which, in the discoveries of Faraday may be said to have 'cast their shadows before.' The various meteors described are not the offspring of separate causations, but functions of common principles. The intimate connexion of agency, of heat, and electricity is apparent in the *tout ensemble* of the science. The former is the *primum mobile* of meteorology, and oxygen, nitrogen, and hydrogen, the elements on and with which it operates. . . . .

And at another place he observes—

"The experiments of Dr. Faraday have established, 'a true direct relation and dependence between light and the magnetic and electric forces; and thus a great addition is made to the facts and con-

siderations which tend to prove, that all natural forces are tied together and have *one common origin.*' "*

We are the more confirmed in this when we reflect, that unless the atmosphere had been formed on the *second* day of the Mosaic week, there would have been an *unaccountable hiatus* in the narrative of that period, as regards the LIGHT, that potent element so recently introduced into the universe amongst the works of the Creator. We have clearly shown, that it was this which was made use of on the *first* day to cause the earth—and we conclude the other spheres also—to rotate around their respective axis; and we have likewise made it manifest, that the primary light was employed by the Creator on the *third* day in separating the water from the land, and in forming the phanogamous classes of the vegetable kingdom. Consequently, unless there was a commensurate amount and importance of work performed, under divine direction and power, by the same wonder-working element, the primary unconcentrated light, on the *second* day, there would be the hiatus we alluded to: and unless that work was the firmament or atmosphere, we candidly confess we shall be at a loss, and wholly unable to account for it during a period, when we positively know, by what it was made to do both before and after, THAT IT DID EXIST. While all our conceptions of the Deity and his works forbid us, even to suppose, that it could have been allowed to remain, during the *second* day, unemployed or unproductive.

We have already adverted to the fact, that however influential and all-pervading the centrifugal force, which was engendered by the first rotation of the earth around its axis, must have been; and however certainly it would have the effect of repelling part of the primitive circumfluent water to a considerable distance beyond its original level; and, to a certain extent, filling with its comminuted particles part of the space now occupied by the atmosphere; yet, *the force in question, so long as it was unaided, was quite incapable of having sent any particles of a material description to such a distance as forty or fifty miles from the earth's surface*—a

* Introduction to Meteorology, 1849, pp. 440, 278.

height to which it is ascertained the firmament or atmosphere actually extends. It is when labouring under this difficulty that we recognise in the principle of diffusion, or the alliance of the material bases of the atmospheric elements with the expansive principle of light, whereby they are buoyed up to the height in question, an admirable and simple explanation; the true *rationale* of what, otherwise, would have been wholly inexplicable, upon the supposition of the centrifugal force alone having effected the object in question; and in this we have a fresh incentive to be grateful to science, for the discovery which not only has relieved our mind from anxiety on this score, but has served to manifest in so much clearer and more forcible a manner the wonderful wisdom and the power of the Creator.

Before proceeding farther we would pause a moment to reflect upon the signal corroboration of the Dynamical Theory, which is afforded by what we have been endeavouring to describe. Unless the inspired historian had recorded, that at this precise juncture the atmosphere had been formed—an aggregate body, be it observed, consisting of the enormous load of matter which causes a pressure, or, what is equivalent thereto, which weighs 15lbs. for every square inch of surface of the terraqueous globe!—without the record of the formation, at the period alluded to, of so vast an aerial ocean, this theory would have been brought to an abrupt and unsatisfactory termination.

It cannot have been forgotten, that when we were endeavouring to explain, in previous sections, what took place, underneath the dark and atmosphereless water of the primitive ocean, when the stratiform masses of the earth's outer crust were being deposited and constructed, we showed that this essential labour was mainly conducted by innumerable tribes of zoophytic, testaceous, and others of the invertebrate class of animals, and by the secretion of widely-extended patches of flowerless, submerged plants. And, that after the animal existences had encrusted themselves with coatings of carbonate of lime, and had fulfilled their other destinies, they died; and from the decomposing materials of their fleshy remains there arose never-ceasing streams of ammoniacal and other gaseous exhalations,

in small, almost imperceptible increments, it is true, but in consequence of the myriads on myriads of these invertebrate creatures, and the ages during which these decomposing processes were going on, they amounted, in their aggregate, to enormous accumulations; and that by means of the plants, in a somewhat analogous manner, the ancient water became surcharged with free oxygen.

We also made manifest, that in conducting the double process of forming and causing the deposition of the mineral stratified crust of the world, and in purifying the universal menstruum, to fit it for becoming the present seas, it pleased the Creator, in the infinitude of his wisdom, and by means of the various agencies employed for that purpose, *to separate the original contents of the primeval water into two distinct divisions:* one of which, by organic agency and electrical influences, he caused to be concreted into solid, indissoluble masses, which thereby descended to and remained at the bottom; every particle of matter in the primitive water fitted for such purposes having been drawn downwards, and become consolidated into strata, was detained until the time of his good pleasure, when, by means of the centrifugal impetus of the first rotation, these solidified deposits were made to start up and stand erect, to form the rocky barriers of the residual water. *Of this solid and enduring section of the primary matter we have given a sufficient and a satisfactory account.* They now constitute the upheaved barriers of the ocean; the stratiform masses of the world!

The other section of the matter, which was thus being divided during the process of purification, took an opposite direction and went *upwards.* We made it perfectly apparent, that one of the principal ingredients which arose from the decomposition of the submerged animal matter was ammonia, and, that owing to the specific levity of this alkaline substance, or what is the same, its relative size of volume, and the facility with which it combines with water, it percolated *upwards* until it reached the higher strata of the ancient ocean.

We made it quite evident, at the same time, that this state of matters during the incipient period of the earth's history, to which we then did and now do allude, was no figment of the

imagination, but that it did necessarily exist; indeed, could not, according to the laws governing matter, and under the allowed circumstances, have been otherwise. For so surely as there existed successive races of animal forms at the bottom of the primitive ocean, and their fossil exuviæ abundantly testify that there did, so surely must these living, mortal creatures have died; and so surely as they died, so certainly and unavoidably must their fleshy remains have decayed, decomposed, and resolved themselves into those gaseous exhalations which proceed from putrid animal matter, one of which, and the principal one, is *ammonia.*

If the innumerable myriads of living creatures, whose fossilized and indurated coverings compose a vast proportion of the calcareous strata and the prevalence of this description of rock be taken into account; the ages which must have passed whilst these were being formed, and whilst the primeval waters were being brought into a state of preparation to be the seas of the present day be considered; we shall be able to arrive at an approximative conception *of the enormous accumulation of the alkaline ingredient ammonia, and of the free oxygen, which must have been stored up towards the conclusion of the non-rotatory period.* Indeed, we know of nothing short of an aerial ocean, such as the atmosphere, which, with its life sustaining influences, envelopes the whole earth, to the height of nearly 50 miles, whose aggregate weight is that of 5,292,623,739,744,000 tons, or nearly five thousand three hundred billions of tons; and of the *nitrogen* or *azote* alone, which was derived from the ammonia in question, at the enormous weight of 4,093,853,510,757,856 tons; or, in round numbers nearly four thousand one hundred billions of tons, that could possibly have required the protracted accumulations to which we have alluded, and so often insisted upon.

We have singular pleasure in being enabled to give our readers the following remarkable corroboration, so far as it goes, of the approximative correctness of our estimates, which we have met with in Dr. Thomson's recent meteorological work, published some years after our computations were made.

"The weight of the entire atmosphere is equal to a sea of mer-

cury covering the superficies of our globe to the depth of 30 inches. The pressure is equal to nearly 14.6lbs. avoirdupoise upon each square inch, or, 58,611,548,160lbs. upon every square mile. The pressure of the atmosphere may be thus estimated at about 8 ozs. avoirdupoise for every inch of mercurial elevation of the barometer. The absolute weight of the atmosphere, assuming the superficies of our globe to be 790,116,426,647,756,800 square inches, amounts to the enormous sum of 11,456,688,186,392,473,600lbs., equivalent, according to Dr. Cotes, to the weight of a globe of lead 60 miles in diameter. Pascal computes the whole mass of air at 8,983,889,440,000,000,000 Fr. lbs. Thus the weight of the atmosphere is equal to above eleven trillions of lbs. *English notation*, a sum which words may express and figures tabulate, but the mind cannot appreciate. Reduce this amazing weight to tons, and the mind is still unable to conceive the full value of the product—5,114,592,940,353,782. Compared with the weight of the globe this mighty sum dwindles to insignificance. Unite the two, and none but an Almighty mind can form an adequate conception, none but an Almighty arm could hurl it through space, and give to its motions a regularity obedient to fixed laws. The same Almighty power alone could institute these laws."*

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* Introduction to Meteorology, p. 25.

It may be interesting to some of our readers, to know by what process we arrive at this array of figures, representing the weights of the whole atmosphere, and of the azote in it, respectively, in billions of tons, quantities scarcely appreciable by the mind, yet deduced from undeniable data.

We have, first of all, the diametres of the earth, 7,899 and 7,925 miles, and assuming the surface to be level, we have for the entire superfice, 196,878,115 square *miles*, and consequently 790,365,145,135,104,000, say seven hundred and ninety thousand three hundred and sixty-five billions one hundred and forty-five thousand one hundred and thirty-five millions one hundred and four thousand *square inches*; and as the aggregate weight of the atmospheric elements is equal to 15lbs. for every one of these square inches, we have, of course, one ton of 2,240lbs. equal to square inches 149,333, which becoming the divisor of the above surface in square inches, gives 5,292,623,739,744,000 tons as the weight of the entire atmosphere.

The *azote* being estimated at 77.55-100ths of the weight of that body, we have, of course, to take 790,365,145,135,104,000 × 0.7755 = 611,347,439,762,002,944 ÷ 149.333 = 4,093,853,510,757,856 tons for the azote alone.

Will this world-wide retort, this atmosphere—in which are stored up, in combination with the expansive principle, the ammoniacal exhalations of so many by-gone generations of invertebrate creatures—ever reveal to man the lapse of ages which passed while as yet the earth was without rotation? Will it ever, by its known weight of azote, be made an index of undenoted time? If there be found to be any connexion between, or any proportion common to,

And had not, therefore, the divine historian opportunely enabled us to account for the subsequent destiny of these atmospherelike accumulations, we would have been wholly at a loss; indeed, we could, by no other means, have given any information respecting them whatever. They must have remained a blot upon and an insuperable obstacle to the perfecting of the Dynamical Theory.

Whilst repassing and preparing this work for the press, we were very much struck with the coincidence, to a certain degree, of the following passages in "Mr. Whitehurst's Enquiry into the original Formation of the Earth." In giving them we need not, we presume, remind our readers how widely we two differ in our cosmographical conclusions; nevertheless, there are passages of remarkable approximation, by which we feel encouraged, and others, again, wherein that learned and good man seems evidently at fault; but which the Dynamical Theory satisfactorily explains while it removes the difficulty. The following passage of shadowy agreement has allusion to the subject of "separation during," what he calls, "the *chaotic* period:"—

"These matters being duly considered, it will evidently appear, that the component parts of the chaos no sooner became quiescent than similar particles began to unite and compose bodies of various denominations. . . . . . The uniform suspension of the component parts, which had hitherto prevailed throughout the chaotic mass, being thus destroyed by the union of similar substances, bodies of the greatest density began their approach towards the centre of gravity, and those of the greatest levity ascended towards the surface.

Thus apparently commenced the separation of the chaos into *air*, *water*, *earth*, and other select bodies. Now, as the specific gravity of air is to that of water, nearly as 1 is to 800; according to the

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the duration of a mollusc and the amount of ammonia rendered up by its decaying remains, whereby the longevity of an ancient mollusc would be to the duration of a modern one as their respective exhalations, and the data were ascertained by the latter, then some approximation might, perhaps, if considered necessary, be come to as to the whole period required to produce the azote of the atmosphere, and consequently the period of non-rotation, due allowances being made for all other attendant circumstances, and proportional periods allowed for the prior formations containing no organic remains.

laws of statics, the former became freed from the general mass in a like proportion of time sooner than the latter, and surrounded the terraqueous globe with *a muddy impure atmosphere.*"

And again, in the recapitulation—

"Then commenced the separation of the component parts; for those of the greatest density began their approach towards the centre of gravity; and those of the greatest levity ascended towards the surface; therefore, as the specific gravity of air is nearly 800 times lighter than water, the presumption is great, that the former was sooner freed from the general mass than the latter, and formed a *muddy impure atmosphere*, surrounding the newly formed globe; water being next in levity, succeeded the *air*, and universally encompassed the earth in one vast ocean. In process of time these elements became perfectly pure, and fit for animal life."*

The proper consideration of all that has now been brought forward, respecting this evident two-partite division of the associated elements of the ancient ocean, taken in combination with the explicit announcements made in those parts of Scripture to which our writings have reference, unfold to the mind a remarkable uniformity of proceeding and oneness of design, both *before* and *after* the rotatory period: this event, important as it may appear, and as, in reality, it was to the whole material universe, exercised not the slightest influence over *the great leading principles which continued uninterruptedly to direct the entire plan of creation.* By what has just been demonstrated it is evident, that the operation of separating masses of matter into two, by causing one division to unite itself closer with *gravity* and to go downward, and by associating another portion of the same mass with *expansion*, and induce it thereby to adopt an opposite or an upward tendency, had been going on for ages before the formation of the physical light. When this was willed into existence, the first impulse given to it was *to divide it from the darkness.* By the application of the expansive influence, the spheres were caused to rotate, the waters *under* the firmament were *divided* from

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* Enquiry into the Formation of the Earth, London, 1786, pp. 34, 277.

those *above* the firmament. And, in continuation, the residual waters were *separated* from the dry land, and the two unitedly stood forth, in pleasing variety, as a fitting pedestal for the plants and animals of the more recent world. Whilst the same principle seems to have been carried out even in the formation of these; for animal and vegetable organic forms, endowed with life and vegetable vitality, were *separated* from the more inert materials which constituted the terraqueous globe. In short, the great leading feature of the creation seems to have been SEPARATION. A separation between that which was, and which still continues to be, to a certain extent, under the influence of ATTRACTION or DARKNESS, and that which, by the immediate agency of the Creator, has been immutably placed also, in degree, under the dominion of LIGHT or EXPANSION.

So far as has been revealed we are enabled to trace the extent of this principle of *separation;* how far it really extends, is not for us, as finite beings, to enquire. The veil which has been thrown over this subject we dare neither touch nor attempt to draw aside: our becoming position is reverential obeisance before it, and to His will who alone knoweth or can know, what might have been the consequences had He not stretched forth His hand "at the beginning," and overruled the influence of "the darkness which reigned upon the face of the universe!" This course, which fortunately puts all conjecture at an end, *has been adopted;* and our duty now, in place of seeking "to interfere in things which are too high for us," is to receive with reverence, thankfulness, and faith, the revelation which has been made to us respecting it; and, whenever in our power, to endeavour to apply the knowledge, which we have thus acquired, to the glory of the Creator.

SECTION VII.

METEOROLOGICAL PHENOMENA RESULTING FROM THE LIGHT, AND FROM THE EARTH'S PROTOROTATION.

CHAPTER XXIX.

The subject of the previous Chapter continued. Atmospheric phenomena. Scientific evidence of the manner in which the *Aerial* and the *Aqueous* portions of the Atmosphere respectively act under the influence of a common cause. Scriptural and philological confirmations of these announcements. Application of the information acquired from both of these branches, to the further elucidation of the Dynamical Theory.

Following up the design, which we contemplated in the previous chapter, of preparing the mind for the investigations which we shall soon have to undertake in a subsequent part of this work, we shall now proceed to enquire into some of the other conditions of the atmosphere, namely, the manner in which the aerial and the vaporous portions conduct themselves under meteorological changes affecting them both. For this purpose let us refer to the *eighty-eighth* Theorem, which states, "*That when a space is filled with a mixture of gas and vapour, these two bodies act, under changes of volume, in exactly the same manner as they would if each separately occupied the whole space; the gas dilates and contracts, changing its pressure and temperature with its density. The vapour obeys the same law, so long as no part of it is condensed into a liquid; but as compression renders condensation more easy by the more rapid development of heat, when much compression is used, a portion of that caloric necessary to maintain the vapour in the aeriform state will escape. A corresponding quantity of the vapour will become liquid; and the remainder will be mingled*

with the gas, having the same tension which it would have if the gas were not present." And in connection with this, we shall again refer to a clause of the *ninety-third* Theorem, although it has been already recapitulated, "*That whenever,*" *by any meteorological cause,* "*the temperature of the air is reduced below the limit at which the suspended vapour is maintained in a state of saturation, condensation takes place, and rain or aqueous clouds are produced.*"*

The following are some of the evidences, bearing upon those points which it may be satisfactory and interesting to peruse:

"Clouds," says Professor Whewell, "are produced by aqueous vapour, when it returns to the state of water. This process is *condensation*, the reverse of evaporation. When vapour exists in the atmosphere, if in any manner the temperature becomes lower than the *constituent temperature* requisite for the maintenance of the watery state, some of the steam will be condensed and will become water. It is in this manner that the curl of steam from the vent of a steam boiler becomes visible, being cooled down as it rushes into the air. The steam condenses into a fine watery powder, which is carried about by aerial currents. Clouds are of the same nature with such curls, the condensation being generally produced when air, charged with aqueous vapour, is mixed with a colder current, or has its temperature diminished in any other manner. Clouds produce *rain*. In the formation of a cloud the precipitation of moisture probably forms a fine watery *powder*, which remains suspended in the air in consequence of the minuteness of its particles; but if from any cause the precipitation is collected in larger portions and becomes *drops*, these descend by their weight and produce a shower."

At another part of his Treatise, when noticing the laws of electricity, he adds—

"We cannot trace very exactly the precise circumstances in the occurrences of the atmospheric regions, which depend on the influences of the laws of electricity; but we are tolerably certain, from what has been already noticed, that if these laws did not exist, or were very different from what they now are, the action of the clouds and winds, and the course of vegetation, would also be other than it now is. It is, therefore, at any rate very probable that electricity

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* See also 94th Theorem and evidences.

has its appointed and important functions in the economy of the atmosphere, and this being so, we see a use in the thunder-storm and the stroke of the lightning. These violent events are, with regard to the elasticity of the atmosphere, what winds are with regard to heat and moisture. They restore the equilibrium where it has been disturbed, and carry the fluid from places where it is superfluous to others where it is deficient. In the natural world, these apparently destructive agents are, like all the other movements and appearances of the atmosphere, parts of a great scheme, of which every discoverable purpose is marked with beneficence as well as wisdom."*

"When the air," says the author of the 'Philosophy of Storms,' "near the surface of the earth becomes more heated, or more highly charged with aqueous vapour, which is only 5-8ths the specific gravity of atmospheric air, its equilibrium is unstable, and upmoving columns or streams will be formed. As these columns rise their upper parts will come under less pressure, and the air will therefore expand; as it expands, it will grow colder about one degree and a quarter for every hundred yards of its ascent, as is demonstrated on the nephelescope.

"The ascending columns will carry with them the aqueous vapour which they contain, and, if they rise high enough, the cold produced by expansion, in consequence of diminished pressure, will condense some of the vapour into cloud; for, it is known, that clouds are formed in the receiver of an air-pump when the air is suddenly withdrawn. The height to which the air will have to ascend before it be cold enough to form clouds is a variable quantity, depending on the number of degrees which the dew-point is below the temperature of the air. . . . . . And the difference between the dew-point and the temperature of the air in degrees is called the complement of the dew-point."†

"Mists and clouds," says Mr. Hutchinson, "seem to consist of a multitude of hollow vesicles or bladders, the coatings of which are inconceivably thin, and similar in structure to those usually blown from soapsuds. These vesicles vary in size, according to the measurement of de Saussure, from $\frac{1}{4222}$ to $\frac{1}{2620}$ of an English inch in diameter. . . . . . This is farther proved by the circumstance of

* Bridgewater Treatise, pp. 85, 89, 111, 112.

† Introduction, pp. viii. lx.

their specific gravity being such, that they remain suspended in the air without any tendency to descend, and even on frequent occasions are seen to ascend; whereas, if they consisted of round drops, without any internal vacuity, their descent would be rapid. . . . . .

"Clouds, in order to their suspension, must displace a weight of atmosphere equivalent to their own. The dissolution of clouds is effected in two ways, viz.—by falling in rain, or by evaporation and reconversion into invisible vapour.

"That the formation of clouds is a necessary antecedent to rain, is proven by the fact, that rain never falls unless the sky immediately vertical be obscured by clouds. But though clouds be essential to its production, they never produce it until they have acquired a considerable degree of density. But how does it come about that the aqueous vesicles lose their vesicular form, and descend to the earth in drops of rain? . . . . . Upon reflecting on the different degrees of rapidity with which rain falls at different times, and in different climates, I am disposed to think that the capacity of the atmosphere for suspending aqueous vesicles is limited, and varies with its temperature; and from the greater density of clouds in warm climates, as well as the greater amount of rain which falls from them in a given time, it seems probable that the capacity of the air for suspending vesicles, like its capacity for holding moisture in invisible solution, increases with its temperature. . . . . . Provided other things be equally favourable, the annual amount of rain that falls, and the heaviness of the showers, are greatest at the equator, and diminish as we ascend towards either pole. . . . . . While the rainy direction of winds, in all latitudes beyond the tropics, is when it blows in the lower half of the atmosphere from a warm towards a comparatively cold climate."*

"When the air can no longer retain the moisture blended with its particles," observes Dr. Thomson, "it descends in drops upon the earth, purifying the atmosphere through which they fall, and fertilizing the ground with refreshing rain. This, or melted snow, is the purest of natural waters, though, in consequence of its solvent power, it generally contains some extraneous ingredients. . . . . . The amount of rain, or meteoric water, which falls upon the ground is greatest in the tropics, and decreases as we approach the poles.

* Principles of Meteorology, by G. Hutchinson, pp. 122, 152, 172, 196, 197, 321.

The physical features of the locality influence considerably the quantity. . . . . . It was reserved for Sir John Leslie to illustrate what Hutton satisfied himself with merely enunciating respecting the production of rain. 'Suppose,' says Sir John Leslie, 'equal bulks of air in a state of saturation, and at the different temperatures of 15° and 45° cent., were intermixed, the compound arising from such union will evidently have the mean temperature of 30 degrees. But since, at these temperatures, the one portion held 200 parts of humidity, and the other 800, the aggregate must contain 1,000 parts, or either half of it 500; at the mean or resulting temperature, however, this portion could only suspend 400 parts of humidity, and consequently the difference, or 100 parts, amounting to the 200th of the whole weight of air, must be precipitated from the compound mass.' But this commixture simply, of strata of humid air at different temperatures, will, in most cases, produce a very small effect, though sufficient to account for the production of a shower. The aid of electricity, as Dr. Traill observes, must be called in to furnish a satisfactory explanation of all the phenomena. In endeavouring to explain the suspension of the clouds, the individual particles were found to be charged with, and surrounded by, electricity. It is merely necessary that this should be withdrawn to have a coalescing of the vesicles and their precipitation, or upon the approximation of clouds charged with electricity in its opposite states, the attraction of the humid spherules, their coalescence, and descent, either to the earth or for the formation of a cloud in a lower strata of the atmosphere."*

We adduce with satisfaction, the following evidences from Scripture, in addition to those which we have drawn from secular sources, while it is distressing to consider how long pearls of such price have lain neglected, though strewed in man's direct path. And more particularly when we observe him watching with so much earnestness and downcast vision, the effects of a discharge of voltaic electricity in a receiver of gas, while He that caused His magnificent lightnings to produce rain in the great laboratory of nature, has been for ages sounding the momentous results, upon a magnificent scale, into man's averted ears!

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* Introduction to Meteorology, pp. 132, 133, 147.

"Whence then cometh wisdom? and where *is* the place of understanding? God understandeth the way thereof, and he knoweth the place thereof. For he looketh to the ends of the earth, *and* seeth under the whole heaven. To make the weight for the winds,* and he weigheth the waters by measure. When he made a decree for the rain, and a way for the lightning of the thunder. . . . . . And unto man he said, Behold, the fear of the LORD, that *is* wisdom; and to depart from evil *is* understanding."†

"By the breath of God frost is given; and the breadth of the waters is straitened. Also by watering he wearieth the thick cloud; he scattereth his bright cloud. And it is turned round about by his counsels; that they may do whatsoever he commandeth them upon the face of the world in the earth."‡

"Who hath divided a water-course for the overflowing of waters; or a way for the lightning of thunder; To cause it to rain on the earth, *where* no man *is; on* the wilderness, wherein *there is* no man; To satisfy the desolate and waste *ground,* and to cause the bud of the tender herb to spring forth? Hath the rain a father? or who hath begotten the drops of dew? Out of whose womb came the ice? and the hoary frost of heaven, who hath gendered it? The waters are hid as *with* a stone, and the face of the deep is frozen."§

"Behold, God *is* great, and we know *him* not; neither can the number of his years be searched out. For he maketh small the drops of water; they pour down rain according to the vapour thereof, which the clouds do drop *and* distil upon man abundantly."||

"Whatsoever the Lord pleased, *that* did he in heaven, and in earth, in the seas, and in all deep places. He causeth the vapours to ascend from the ends of the earth: he maketh lightnings for the rain: he bringeth the wind out of his treasuries."¶

"When he uttereth his voice, *there is* a multitude of waters in the heavens, and he causeth the vapours to ascend from the ends of the earth; he maketh lightnings with (or for) rain, and bringeth forth the wind out of his treasures."**

Before leaving this part of our subject, we cannot refrain from adverting to the pointed manner in which the evidence

* How conformable is this to modern philosophy, which teaches, *that winds propend to the rarefied parts.*

† Job xxviii. 20, 23—26, 28. ‡ Ibid xxxvii. 10—12.

§ Ibid xxxviii. 25—30. || Ibid xxxvi. 26—28. ¶ Psalm cxxxv. 6, 7.

** Jeremiah x. 13.

brought forward corroborates a leading principle laid down by us at the commencement, with respect to the announcements in the first chapter of Genesis, namely—"*That a change of name implies a modification of character.*" Nothing can be made more manifest, than that the *aerial body* of the atmospheric ocean possesses a character entirely distinct from the *vapourous portion* of the atmosphere; and with relation to certain elements, such as heat, wholly different and opposed to it; while a third position has been as clearly and convincingly demonstrated, namely, that unitedly, these two fluid masses, the one contained, as it were, in the interstices of the other, possess a character, and produce effects, different from what they could have done, had they remained uncombined; and likewise, that without being chemically united, and thereby resulting in a *third* substance unlike to either, although in mechanical combination, and each retaining its own individual character, they nevertheless, conjointly, produce results which, separately, neither could have effected.

Now, this peculiar adaptation of means to the end, the most beneficent and life-sustaining which could have been devised, is not only clearly indicated by the phraseology of Scripture,* but there is an evident design exhibited by what is therein said; and which is expressly required when a close accordance is sought between the recorded narrative of events, which no mortal eye beheld, and the announcements of modern philosophy, which have so far successfully unfolded the arcanæ of the atmosphere. By reference to the section of Scripture to which we allude, it will be manifestly seen, that the aerial part of the atmosphere was formed with perfect distinction from the aqueous portion, because the one, after being formed, was itself made the means of effecting the other. "Let there be a firmament in the midst of the waters, and let *it* divide the waters from the waters." The emphatic "*it*" therein mentioned, or the *firmament* being that, which was to effect the division between waters and waters, afterwards shown to have been those waters "which were *under* the firmament from those waters which were *above* the firmament." For it is perfectly

* Genesis i. 6—8

conclusive, that before the firmament could have produced any effect, it must, itself, have been made. No sooner, however, is it constituted, than the Creator employs it to produce a consecutive series of effects, namely, to separate, in space, those waters which were combined with, what we must for the present and for the sake of our argument call, *something else*, and so made to be *above* the firmament's constituent temperature, from those which were *less* combined with the same entity, and so were *under* its constituent temperature. Nothing can be more evident, than that it could not have been the atmosphere itself with which those waters were combined, in order that they should become *above* the firmament. It is foreign to the law of cause and effect, that any lighter body, by combining with a heavier body, can confer upon the latter a buoyancy *greater than itself.* Again, we need scarcely hesitate a moment to come to the conclusion, that it was *not* darkness, or attraction with which that portion of the water was combined, which became *above* the constituent condition of the firmament, for the primeval ocean had been, as it were, swathed in darkness for ages without any such effects having been produced; nor, indeed, were they produced until the most subtile and buoyant of all elements, LIGHT, was introduced into the material universe; and then, immediately thereafter, the firmament is stretched forth as the handiwork of the Creator. We shall perceive this more clearly when we further consider, that it was the impartation of LIGHT to the more material elements, which principally occupied the attention of the Omnipotent during the period which He selected for perfecting the creation. That LIGHT was the chief agent employed in carrying on those works, the assurance that the phenomena, which we are now more immediately contemplating, required LIGHT, and LIGHT only, to render them complete and intelligible, will greatly add to our convictions that we are on the straight path to a right elucidation; and more especially so, should we adopt M. Peltieri's theory, in which he connects the phenomena of electricity with those of light and heat, upon the undulatory hypothesis of those fluids.

This consideration will appear the more to be relied upon when we reflect, that it is precisely when we are most at a

loss to explain, how any material substance whatever could have been repelled to a distance *of nearly fifty miles from the surface* by the only force which we can recognise as at all likely to have effected this, namely, the centrifugal impetus of rotation, that the discovery of the innate diffusion of the gaseous elements of the atmosphere, or their permanent connexion with the buoyant principle of light, comes opportunely forward to relieve us from our difficulty.

To remove, entirely, the scruples of any who may still be disposed to doubt whether these elements of the atmosphere may not owe their extreme elevation to the centrifugal impetus of the first diurnal rotation, we have only to recur to those laws of mechanical momentum, whose aid we have already so frequently and so successfully sought, to be wholly convinced by them, that it would be the *heavier*, and not the *lighter* materials composing the non-rotating spherical earth's surface which would, on the eventful occasion of its rotation, have been thrown farthest into space, or further from the centre; for, according to the *fifth rule* of the *seventy-third* Theorem, "*Weights which are as one to two, revolving at equal distances, with the same velocity, will have their centrifugal forces as one to two; the centrifugal force increasing as the mass of the moving body increases;*" an insuperable law of matter, which, wherever gravity exists, must put an end to any lingering conception, that it might have been the earth's first rotation which expanded the watery vapours and aerial ingredients of the atmosphere to their present elevated position above the surface of the earth and sea.

A closer investigation into the reasons assigned by meteorologists for the formation and suspension of clouds and visible vapour in the atmosphere, will abundantly prove, that they *assume*, as a fundamental position, although they do not expressly assert it to be so, that the aerial portion of the atmosphere was formed *before* the vapourous or aqueous portion.

The following passages will tend to show this:—

"Clouds consist of small hollow bladders of vapour charged each with the same kind of electricity. It is this electric charge which prevents the vesicles from uniting together, and falling down in the

form of rain. Even the vesicular form which the vapour assumes is probably owing to the particles being charged with electricity. The natural repulsion of the electric particles may be considered as sufficient (*since they are prevented from leaving the vesicle by the action of the surrounding air*, and of the surrounded vesicles) to give the vapour the vesicular form."*

"That clouds and mist consist of hollow vesicles, is further proved by the circumstance of their specific gravity being such, *that they remain suspended in the air*, without any tendency to descend, and even on frequent occasions are seen to ascend; whereas, if they consisted of round drops, without any internal vacuity, their descent would be rapid. Water is 828 times heavier than air; and it has been calculated that a drop whose diameter is no more than $\frac{1}{1000}$th of an inch would acquire a descending velocity of nine or ten feet per second. . . . . .

"It might be supposed, that *the atmospheric compression would prevent the aqueous particles from originally assuming the vesicular form. But be it recollected, that this is only one force acting against another. Without the compressing force of the external air*, the mutual repulsion of the particles of surplus electricity, would distend the vesicles until they burst from the thinness of their coating. Hence, *the atmospheric compression may be* conceived to be the cause which counteracts the mutual repulsion of the particles of surplus electricity, so as to limit the distension of the vesicles to the dimensions previously stated. . . . . .

"It is obvious, *that the aqueous vesicles comprising clouds must, by some means or other, displace an amount of air, the weight of which is exactly equal to their own weight.* If they displaced more, their specific gravity would be less than that of the air by which they were surrounded, and they would consequently ascend to a higher altitude; if they displaced less, their specific gravity would be greater than the air by which they were surrounded, and they would accordingly descend to a lower level. . . . . .

"There is, therefore, no other way of accounting for the specific lightness of the aqueous vesicles than by supposing that they, by some means or other, *prevent the aerial particles approaching so near their surfaces as the particles of air do to each other.* But how this effect is produced it is not easy to conceive. . . . . . But judging from the fact, that the different denominations of clouds often float

* Dr. Thomson on Electricity and Heat, p. 440.

for a length of time at the altitude in the atmosphere where they are formed, without any apparent tendency to ascend or to descend, it may be concluded, *that the original specific gravity of the vesicles of which they are severally composed, is determined by the density of the atmosphere where they are formed.* If it be admitted that the vesicular shape is produced by the mutual repulsion of the particles of electricity evolved during the precipitation and conversion of invisible vapour into mist or cloud; and if it be admitted *that the atmospheric compression is the force which prevents the distending of the vesicles till they burst*, it is obvious, *cetera paribus*, that the distension of the vesicles and the thinness of their particles will be greater, and their specific gravity less, according *as the air is less dense at the place where they are formed*, and hence the specific gravity of the vesicles composing clouds will be proportioned *to the density of the atmosphere at the time and place of their formation.*"*

The following corroborative evidence is from Dr. Thomson's recent introductory treatise on this complicated branch of philosophical study:—

"According to Halley," observes that writer, "the vesicles of fogs are hollow. From the optical phenomena presented, and explained by Kratzenstein, there seems no reason to doubt the correctness of this opinion. Professor Käuntz gives to these vesicles a mean diameter of 0.0224 millimeter, or nearly 1-1250th of an English inch. He has found that the season influences their size; thus they are twice as large in winter as in summer, the maximum being from December to February inclusive, and the minimum in May and August, the smallest being found in the latter month. The humidity of the atmosphere was observed to modify their magnitude. Drops of water are mingled with these hollow globules. . . . . . Clouds differ from fogs in their altitude and suspension, but in composition they are alike, having these ultimate constituents for their ingredients. The proximate cause of their formation is the loss of caloric in the humid atmosphere, and condensation of the moisture; but we are still ignorant of the ultimate cause of the phenomenon. Of their mode of suspension, their specific gravity being lighter than that of air, some have received this as a satisfactory explanation, but it is far from being cogent. Professor Stevelly

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* Principles of Meteorology, by G. Hutchinson, pp. 152, 155, 158, 160, 164.

of Belfast, offers a theory combining the gravitating force of the vesicles, which through their extreme minuteness is exceedingly trifling, for the weight decreases directly as the cube of the radius, with an electrical hypothesis to be immediately referred to. A far more plausibe theory than the first, attributes it to currents, upward and horizontal. Another hypothesis assigns it entirely to electrical agency. We know that electricity has much to do with the phenomenon; it is largely developed during evaporation, as was long ago shown by Volta, Saussure, Lavoisier, La Place, and Bennet, and the vapour acquires that form denominated *positive*, while the water which remains is *negatively* charged, terms arbitrary but convenient, indicating *one* electricity in one or other of its separate conditions. . . . . . In whichever state the electricity exists in clouds in the aggregate, there will be a repulsion and attraction of the particles, by virtue of the law, that bodies similarly electrified repel, while those in the opposite electric states attract each other. As the temperature of the vapour decreases, and the humidity becomes condensed, its capacity for electricity lessens and a portion separates. It is easy to conceive that this electricity accumulates around the individual molecules, and prevents the coalescence of the vesicles into drops, the specific gravity of which would cause their precipitation. Thus they are buoyed in the air till other influences cause their descent."*

That moisture, or aqueous vesicles, are considered by the inspired writers of Scripture to be the natural produce or "fruits" of the delicate and complicated machinery of the atmosphere, which was there put up and set to work, with so much God-like comprehensiveness, invisibility, and simplicity on the second day of the Mosaic week, we have the most irrefragable proof, in that short but sublime passage of Haggai's denouncement in consequence of the desolate condition of the Temple, when he exclaims to the disobedient people of God, "Ye looked for much, and lo, it came to little; and when ye brought it home, I did blow upon it; and why? saith the Lord of hosts. Because of mine house that is waste, and ye run every man unto his own house. Therefore the heaven over you is stayed from dew, and the earth is stayed from *her* fruit."†

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* Introduction to Meteorology, pp. 115, 123, 124. † Haggai i. 9, 10.

An attentive perusal of these several passages (some of which we have taken the liberty to put in italics), as well as a reference to any other treatise on meteorology, will convince every one, that no *rationale* of the phenomena connected with this department of nature can be attempted without the clear and well understood assumption of the pre-existence (we mean merely in the *order* of time) of the aerial body of the atmosphere; not only for the suspension of the aqueous vesicles when once formed, but as indispensable towards their *original formation*. The air, itself, being one of the equipoising forces, by whose mutual reaction, on the aqueous vapour, these very vesicles are formed, heat and electricity *within* causing their distention into the vesicular construction, the atmosphere *without* restraining these humid globules from destructive explosion, and regulating their form and specific gravity by its own density or pressure.

These multiplied effects being the result of one single law, "Let there be *a* firmament in the midst of the waters, and let *it* divide the waters from the waters." The formation and coalescing of these congeries of vesicles enabling them to float in the air, in all their varied and attractive forms, while executing the important services for which they were thus "gathered together;" the wisdom and benignity of the Creator shining forth as much in their never-ending change and beauty of form, and the splendour of their reflected colours, as in the welcome refreshment which they bring to the parched earth, and to its fainting inhabitants.

At the same time we must not overlook the fact, that unless there had co-existed the elements of moisture and of heat or electricity, the aerial ocean above would have been a barren, unproductive waste of dry air, floating around and scorching and drying up everything with which it came in contact, "the heavens would have been as molten brass over our heads." The union of these separate formations, and in the peculiar way in which they are connected; the one permeating the other, and acted upon diversely by the same cause, seem as essential to the perfection of the whole, as was the aerial body in which the vesicles of moisture float; without this atmosphere, even although moisture, heat, and electricity had

existed, there never could have been a single aqueous globule brought into visible form; while lacking this initial and important component of clouds and mists, we should have been deprived of the requisite meteorological machinery, so indispensable for the transference, from the ocean to the land, of those refreshing showers with which all departments of organic nature are now so opportunely blessed.

No deduction from admitted premises can be more clear or logical than this. It is the natural consequence of the announcements of philosophy. The aerial ocean first; the aqueous associate afterwards; while the whole tenor of the inspired narrative is equally clear and conclusive to the same effect. "And God said, Let there be a firmament in the midst of the waters, and Let IT divide the waters from the waters. And God made the firmament and divided the waters which were *under* the firmament from the waters which were *above* the firmament, and it was so."

On reviewing this simply told, but wonderful account of the formation of the atmosphere, and especially, when we consider it in relation to the findings and declarations of philosophy, we cannot avoid being struck by the effective simplicity and comprehensiveness of the physical laws which are recorded to have been thus impressed on the component elements then present, whereby the atmosphere was called into existence. Every attempt to explain the vicissitudes of the weather concurringly show, that there exists a certain ratio of variation (whose rule, although very nearly discovered, has not yet been absolutely determined) in the influence which the atmosphere exercises in producing those vicissitudes, according to the temperature, altitude, and density of that great aerial body.* And we can conceive no single law more capable of producing such diversified results, than that described in this portion of Scripture, "Let there be a firmament in the midst of the waters, and Let *it* divide the waters from the waters." For, in this we behold a uniform power, the primary light, made to coalesce with a mass, the water of the first day, whose density, and therefore whose capacity for the light, heat, or electricity

* Wells, Whewell, Graham, Thomson, and Hutchinson.

which had been put into active operation, varied according to its altitude, and consequently the resultant power or body would still have diversified influences according to *its* density or altitude. An equal quantity, added universally to an unequal mass, would still leave the entire mass unequal in its parts. It might result in the production of a *greater*, or a *different* description of power, but nevertheless the original inequality would pervade the whole, and cause it to produce corresponding effects.

And, indeed, this was precisely what the firmament was designed to do; clouds, mist, dew, rain, snow, &c., and all the intricate machinery which produces those delightful and healthful vicissitudes of weather we enjoy, are all brought about by this varying power of the firmament, which at any given place, or at any supposable altitude, acts according to its constituent energy in those particular localities; modified, but not overcome, by the minor influences of land and sea, the diversity of surface, or of day and night; rendering it, thereby, almost impossible, to deduce, from data accumulated at any one point, what may be the results at any other, or even at the same point in succession of time, in consequence of the continuity of the aerial ocean, and the action and reaction which the climate and weather of one place produce on the climate and weather of another.

To understand aright how things are, we must endeavour to trace them back to their origin. In the case under consideration philosophy can render us scarcely any further assistance than it has already so sedulously and so admirably accomplished. For philosophy has to deal with things as they are, with the elements as it finds them. It is Scripture alone which can enlighten us regarding that which took place when there was no mortal eye to behold what was done; and, fortunately, with respect to the elements of the atmosphere and its formation, the inspired narrative is extremely clear and explicit. "God made the firmament, and with IT he afterwards separated the waters which were *under* it from the waters which were made to be *above* it, *and it was so*." And, in accordance with this emphatic announcement, it has ever since continued to effect this separation between waters which are

waters which are *above* it, and will do so until the end of time.

"God made the firmament," and who shall either alter or unmake it?

These views of the subject, respecting the action of the new-formed firmament in assisting to complete the machinery of the atmosphere, seem to be borne out and confirmed by a closer and more critical philological examination into the same portion of the Divine Record.

"The Hebrew plural word *shamaim*, translated *heaven*, means etymologically the higher regions, all that seems above the earth: as we say, God on high, God above, God in heaven."*

And we have, in the following words, an explanation given of the same passage from another and altogether distinct source, and which we consider opportune again to bring forward:—

"Then called God, the expansion heaven (or etymologically 'fire-waters'). This name which God bestowed on the expansion sufficiently indicates the nature of the process. It is a compound made up of the word אש fire and מים water, thus denoting that the expansion was formed by a combination of water with the elements of fire; but the expression was more than this. It was to be formed by a separating between waters, and into waters—the waters were to be decomposed, and formed into separate waters, which being united to the elements of fire, were to constitute the fire-waters or heavens."†

In continuation, we take occasion here to record the opinion kindly given to us by a learned Hebrew, as to the philological signification of this particular part of Scripture:—

"Whenever it is desired," said he "fully to comprehend what is implied by the expressions 'And God said, Let there be a *firmament* in the midst of the water,' &c., and more especially by the word firmament, it must always be understood, that there was a process thereby put into operation which caused a body, previously in an amassed state, to expand in such a manner as that *it should assume the form of a wide-spreading envelope of comparatively thin dimensions to that which it enclosed.*

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* Buckland's Bridgewater Treatise, vol. i. p. 21. † Presbyterian Review.

"It will not do to imagine, that what took place was similar to the *swelling out of water into steam*, which expands equally in *all* directions; for, although the word 'firmament' implies *expansion*, even as water does when by heat resolved into vapour, it conveys, at the same time, a *special* meaning, which refers to the expanding laterally, flatly, broadly; and in this modified signification of the expanding of a substance which was before a shapeless mass, we must receive, else we shall not comprehend aright, the import of the words, 'And God said, Let there be a *firmament* in the midst of the waters.'"

On the same side of the question, but by a different approach, science has arrived at a confirmatory conclusion; "*A gas and a vapour, occupying the same space, have a tension equal to the tension of the gas and that of the vapour, or, in other words, a tension equal to their united tensions.*"*

We may, therefore, sum up the whole of the evidence on this point, come from whatever source it may, by affirming, *that it thoroughly proves that* WHERE *a change of designation is made in the recorded portion of the first chapter of Genesis,* THERE *a change of character likewise took place;* a demonstration to which we may, in the sequel of this work, have occasion to revert, and we therefore beg it may be borne in mind.

This closes the evidence which we intend to bring forward from *this branch* of our subject, to assist in proving the fundamental assumption of our theory, namely, *that until the Mosaic week the earth had no rotation around its axis.* No evidences, could, in our opinion, be more convincingly conclusive, so far as the one subject bears upon the other; indeed, had the philosophical part of the evidences been written for the purpose, in place of being quite unconsciously penned as regards this, they could not have been more direct; nor would they have left a more favourable impression upon the mind. To render more indelible the convictions these evidences afford, a recapitulation of their principal points, or leading features; and a comparison of them with the state of the globe at the

* Eighty-fifth Theorem.

period we allude to, may be desirable, in order to show, that all the attendant circumstances were pre-arranged in the most appropriate manner, and with the most perfect wisdom, for the promotion of the operations then taking place.

The *expansive principle* was to be infused into, or introduced amongst the waters; and it was to divide the waters from the waters, by causing a portion of them to ascend, "Let there be a firmament, or expansion (Heb.) in the midst of the waters; and Let it divide the waters from the waters." To facilitate the accomplishment of these two separate acts of divine will, the *attractive influence* which had formerly been exerted over the waters, was, for the time being, to a certain degree invaded by the counteracting influence of the centrifugal impetus impressed upon the water by the rotation of the earth; it being quite obvious to any one who reflects, that a hollow sphere of water, such as then surrounded the globe, must have become much less dense when it increased its diameter, as the waters did, when raised up by the centrifugal impetus, whatever may have been the amount of the increment which they underwent; and therefore, the waters which were to be divided by the expansion, in place of presenting a compact, and comparatively impenetrable body to the influence of the light, by being dispersed through a greater extent of space, were rendered more easy of combination with that subtile fluid; besides, we conceive that by that operation, the primitive ocean was transformed into a body possessing greater differences of density within its own mass, and thereby made more to resemble the atmosphere, than had it remained, as it previously was, before the expanding influence of protorotation was impressed upon it.

The vast extent of surface, in consequence of the whole globe having been surrounded with water; and that surface being expanded by the action of the centrifugal impetus, was likewise particularly favourable for promoting vaporization, "the quantity of water which the ocean dismisses into the atmosphere being in proportion to the extent of surface;"* and again, "the quantity of vapour exhaled is greater where

* Theorem 93 and evidences.

the surface is extensive, and this in proportion to the superficies."*

The absence of the atmosphere, and, consequently, of its pressure, afforded an increased facility to the combination of the expansive principle with water equal to 124 degrees of Fahrenheit's thermometer.† "According to Robinson, fluids boil in vacuo at 140 degrees lower than in open air."‡

In addition to these proofs of the infinite wisdom which were exhibited throughout the whole of this important part of the Creator's work—the formation of "the glorious life-sustaining ATMOSPHERE"—we have to add, that the facility of combination with the LIGHT, towards which all things seem at that particular period to have been made to conspire, would be greatly accelerated by the thrusting up, from beneath and into the water, of those immense masses of heated mineral materials which were simultaneously forming into our present continental ridges and mountain chains; also by the application of the combining principle in a *tangential* direction, as will presently be shown to have been the case; and by the absence of atmospheric pressure—it being declared by the announcements of modern philosophy, founded on experience, "*That the vaporization of a fluid is accelerated by the increase of temperature, and more so when heat is applied where the surface is free from external pressure. In a vacuum vaporization is almost instantaneous.*§

And, finally, the same design was materially aided by the absence of all previous watery vapour in the atmosphere, and the consequent tension arising therefrom; it having been satisfactorily proved, as given in the same Theorem, "that the general rate of evaporation will be in proportion to the tension of the vapour which would saturate the air, diminished by the tension of the vapour which is actually in the air." For, "the more under-saturated the atmosphere is, the drier it is said to be; and the stronger is its influence in promoting evaporation from moist surfaces;"‖ and according to another

* Thomson's Meteorology, p. 101.

† Theorem 54 and authorities.

‡ Thomson's Meteorology, p. 18.

§ Theorem 95 and evidences.

‖ Principles of Meteorology, by G. Hutchinson, p. 17.

writer, "*cæteris paribus*, the rate of evaporation is inversely as the air's density."*

In short, it is scarcely possible that any announcement whatever, could have been more thoroughly in accordance with the facts brought to light, and established by the labours of systematic philosophy, than the declaration which has been put on record in the Word of Truth, thereby evidencing the most undeniable traces of design in the formation, arrangement, and union of all the elements employed in producing the work itself; while the facility which was afforded, by every step in the process, for instantaneous vaporization, harmonises, in the most concurrent manner, *with the shortness of the period* assigned in the Mosaic narrative for its performance. *A whole atmosphere saturated with moisture during part of one day* could hardly be conceived, according to natural causes, without the remarkable concurrence of all those circumstances favourable for its promotion, which we have just shown were present, when it pleased God to will, that it should be so.†

And while it affords so remarkable a testimony in favour of the Divine Record, it likewise establishes beyond the possibility of a doubt, that the formation of the atmosphere took place at the TIME mentioned by the inspired historian, *when there was a concurrence of circumstances favourable to its formation, which have never since presented themselves, nor, as far as we know, were ever present together at one time before.*

We have only one other observation to make, but it is an interesting one. We allude to the design which seems to have been contemplated by the Creator in forming NITROGEN by the instrumentality of myriads of invertebrate apulmonic animals, during innumerable ages, affording us thereby a most remarkable glimpse into the arcanæ of the creation. For we are taught by it, in a manner which admits of no misunderstanding, that while their stony exuviæ were made instru-

* Thomson, p. 102.

† This is in perfect accordance with the fundamental basis of this *Theory*, namely, that God made all things; but that whatever is not specially mentioned in the first chapter of Genesis, was the effect of *natural* causes.—AUTHOR.

mental in forming the solid crust of the earth, the nitrogen which was contained in the gaseous exhalations arising from the decomposition of their animal matter, seems to have been indispensably required to dilute the oxygen of the atmosphere to such a degree as should permit the respiration of animals and plants—and other operations common to the surface—to go on without combustion and destruction; thus appearing to indicate, that there existed some mysterious necessity, whereby *animals without lungs should secrete what was afterwards to enable animals with lungs, and plants with pulmonic appendages, to breathe atmospheric air!* More remarkable still; it may possibly have been, indeed it is almost certain to have been, that during these protracted ages, the subtile elements of which the etherial fluid is composed were being elaborated and caused to expand from the various orbs, into and throughout intervening space, ready to be transformed into physical light, whenever it should harmonize with the everlasting decrees of the Creator, to will the luminiferous fluid into existence; and to bring it to such a state of perfection as, that on examining it, He could pronounce it "Good." And thereafter by dividing it from the darkness, to render it *the great and effectual countervailing principle of the material universe!*—His chief agent during the six days' work of creation.

This is a conception well worthy of being wrought out, and, indeed, when we think of the amazing tenuity of this all-pervading fluid, and consider that it is millions of times more tenuous in comparison with air, than air is when compared with earth, we can hardly hesitate to conclude, that its bases had some such origin; and that it may have required a protracted period of darkness and non-rotation to have formed its elements. "In the beginning God created the heavens and the earth;" consequently, *then all things* were created.

Dr. Thomson, we observe with much satisfaction, seems to coincide in this opinion, while he confirms our own by the manner of stating his.

"Believing," says he, "that the atmosphere is composed of entitities or ultimate atoms, it is evident that a limit does exist; for the

force of gravity drawing each towards the earth's centre, must be greater than the repulsive power of the individual particles, in proportion to the density; and exactly where these forces balance, the extreme boundary will be found. Above this, probably an ether spreads through the planetary regions, meeting the upper limits of the atmospheres of other globes, and stretching forth to the remotest space. Mariotte discovered the law of atmospheric elasticity, that the density or volume of a given quantity of air is inversely as the pressure. Its density at any altitude may be easily found, for, as the elevation is increased in arithmetical progression, the density is decreased in geometrical progression. . . . . .

"Let us imagine," he continues, "a hollow sphere of such magnitude, that the planet Saturn (whose distance from the sun is nearly 900 millions of miles) could perform its solar revolution within it. One single cubic inch of air, as rarefied at an altitude of 500 miles, would fill it entirely. That the eye may behold the vastness of this amount, we give it numerically, 3,053,635,200,000,000,000,000,000,000, or three thousand and fifty-three quadrillions six hundred and thirty-five thousand two hundred trillions of cubic miles, English notation."*

We cannot more appropriately close the evidence for this branch of our enquiry, than in the language of Mr. Donovan, when he offers so just a tribute of praise for the benignity manifested in the formation of the aerial ocean which floats around us:—

"In the constitution of the atmosphere," he observes, "we have ample scope to admire the design and execution of a structure, calculated with such wondrous precision, to fulfil its purposes. Were the atmosphere to consist wholly of oxygen, and the different kinds of objects which compose and are found upon the globe to remain what they are, the world would run through its stage of decay, renovation, and final destruction in a rapid cycle. Combustion, once excited, would proceed with ungovernable violence; the globe, during its short existence, would be in a continual conflagration, until its ashes would be its only remains; animals would live with hundred-fold intensity, and terminate their career in a few hours. On the other hand, were the atmosphere wholly composed of azote,

* Introduction to Meteorology, pp. 23,24.

life could never have existed, whether animal or vegetable, and the object of the Creator in forming this world would not have been fulfilled.

"But the atmosphere is a wholesome mixture of these two formidable elements, each neutralizing the other's baneful influence. The life of animals quietly runs through its allotted period; and the current of nature flows within prescribed limits, manageably and moderately."*

And he might have added, all demonstrating alike the goodness and the wisdom of God the Creator, and demanding the never-ceasing thankfulness of man, the conscious and sentient recipient of these bounties!

In the previous sections of this work we have made manifest, that the materials which constitute the outer crust of the earth were, for ages, preparing under the water of the primeval ocean. And, in this we have demonstrated that those which compose the firmament or heaven,† were also undergoing a similar preparation in the same element. On comparing these conclusions, which are founded on the undeniable evidence of philosophy, with the announcements of Scripture, which state, that "In the beginning God created the heaven and the earth," the strictest accordance will be found to prevail between them; thus affording to every unprejudiced mind the most perfect and surest consolation.

We have now to direct the attention to another very satisfactory coincidence, between the experience of philosophy and the passage of Scripture contained in the fourth verse of the *second* chapter of Genesis—"These are the generations of the heaven and of the earth when they were created, in the day that the Lord God made the earth and the heavens;" on comparing which, it is necessary to pay attention, not only to the arrangement of the words of that verse, but likewise to the words themselves employed to express its meaning.

It must be remembered, that "God called the firmament

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* Chemistry, Cab. Cyc. p. 103.

† We mean this to be irrespective of the more subtile elements of light or etherial fluid.

Heaven." Now, as the oxygen which went to form that, proceeded from the exhalations of plants, and the nitrogen from the decomposition of animal substances, it follows, that both of these must have preceded whatever went to form the solid parts of the earth; and, consequently, during the period of *Creation*, the materials of the heaven anteceded, in strictness of terms, those of the earth; and hence the correctness of the expression, "the generations of the heaven and of the earth when they were created."

But on the other hand, when these materials came to be completed, or *made*, by being each placed in their final positions and relations to one another, then the rocky masses, constituting "the dry land or earth," were placed where they still remain, and the whole outer crust of the earth was finished *before* the elements of the firmament or heaven were completed; and consequently the earth, although *created* after, was *made* before the Heaven, "On the day (or time) when the Lord God made the earth and the Heaven:" and this, too, notwithstanding that the materials of the latter were created before those of the former.

In this remarkable, and to unreflecting readers, *unnecessary* transposition of the words in the verse which we have just quoted, we behold another striking instance of that strict adherence to truth, in the minutest assertions, which characterises the whole Word of God; while the perfect harmony which prevails between the experience of latter times, and the announcements made by the inspired historian upwards of three thousand years ago, evinces in the clearest manner, that he was aware of the previous existence of these materials, and framed the record of their creation and formation in the transposed style in which it is done, in order to accommodate his narrative to the sequence of events. Such information, at that remote period, must have been communicated by inspiration; for no human intelligence could have imparted it to him.

Happily we have thus been permitted to bring our labours to a point which enables us to draw a conclusion we have long desired to effect. Having shown the truth of the Mosaic narrative in all that pertains to matter, with respect to which,

tangible proofs, and evidences appreciable by the senses, deducible from the researches of philosophy, can be made available, we consider ourselves entitled to insist—*That the inspired historian shall be credited, upon his mere assertion, with regard to the remaining and most important term of the whole passage, which admits of no tangible or philosophic proof whatever, namely, that they were all created and made by* GOD; *for he has said, that "In the beginning* GOD *created the heaven and the earth."*

SECTION VIII.

COMPLETION OF THE ATMOSPHERE; SEPARATION OF THE SEA FROM THE LAND; AND THEIR IMMEDIATE COMBINED RESULTS.

CHAPTER XXXII.

First use made, by the Creator, of the newly formed Atmosphere. Separation of the Sea from the Land. This separation effected by VAPORIZATION. Numerous preparatory explanations and advertencies necessary for the effectual prosecution of our argument, and for the establishing of this fact. Different substances vaporized at diverse temperatures: scientific evidences of this. The effects of the application of heat to a solution of salt and water. Results which occur when different descriptions of salts, held simultaneously in solution, are allowed to crystallize; and, also, when these are associated with earthy materials. Concluding proofs on these two points.

IN the preceding chapter we endeavoured to exhibit the accordance which exists between the inspired narrative, and the announcements of experimental philosophy, on points connected with the introduction of the principle of *expansion* into the water of the primeval ocean; the indissoluble union of this buoyant fluid with the ponderable elemental bases of the atmosphere, and the remarkable property which they possess, when so united, of spontaneously diffusing themselves throughout the regions of space, in opposition to the otherwise all comprehensive law of gravity; and, likewise, the separation, from the great body of the water, of a certain portion thereof by means of the same expansive and buoyant influence, and its transformation into the more subtile watery vapour of the atmosphere. When conducting these several branches of enquiry we endeavoured to preserve the uniformity of our design by showing, that these stupendous works of the Creator

were not only thoroughly consistent with the principal features of our theory, but that *their pre-supposition* is indispensable towards a correct conception of how those constituent works were carried on and completed, the centrifugal impetus, of the first rotation, having been one of the secondary agencies employed by the Creator.

In prosecution of our main argument, we shall now endeavour to render the evidences which we may be enabled to adduce, within the compass of this particular branch, conclusive towards the confirmation of the same original position, namely, *the non-rotation of the earth, and its subsequent protorotation,* by showing that the *atmosphere* thus newly formed, and constituted as we have supposed it to have been, was chiefly instrumental in carrying out *the next great steps* in the progressive development of the plan of creation—*the transference of the waters into one place, and restraining them at the level which they now maintain, while by the same process the saline ingredients were separated from the water and deposited in the soil. And, that nothing but a world put into diurnal motion, for the first time, could have produced these effects.*

There can be no doubt, that when the command was issued, "Let there be a firmament in the midst of the waters, and let it divide the waters from the waters," that these, by this means and by the influence of the centrifugal impetus, were maintained at an elevation far above their present level, and even above the highest mountain chains; but it is likewise obvious, that although under such an impetus, whenever they had attained a state of equilibrium, they would, in obedience to the universal law of gravitation, from which they had been only temporarily abstracted, seek and resume their natural level; and, in doing this, had they been allowed to follow, what is now their *natural law,* they would have been *drained* off from the continental ridges into the oceanic hollows which had been prepared for their reception. But there is another truth which, in this case, stands as conspicuously forward, namely, that had this, or could this have been permitted by wisdom which is infinite, a corresponding denudation of the new formed land must inevitably have taken place; and the greater part of its

recently deposited soil and salts would irresistibly have been swept into the oceanic cavities, where they would not only have been of no use whatever, nay, even detrimental, but would have been incapable of fulfilling the commands which were so shortly thereafter to be imposed upon them.

It may be as well to observe, however, at this juncture, that although the Omnipotent Creator cannot be considered necessitated to impose any one law more than any other when constituting nature, yet, when His infinite goodness and wisdom have once induced him to promulgate any law whereby an end is attained, His infinite justice and truth induce him to respect that law; while those attributes operate conjointly in causing all the subsequent laws to be strictly in accordance with those previously given, and with the nature of the object designed to be produced.* With these explanations present to the mind we shall be convinced, that according to the laws which had been impressed on matter, up to the period we are alluding to, VAPORIZATION, by means of the new formed atmosphere, was the method best adapted for separating the land from the water, without exposing the earth to denudation, and the ocean to be re-saturated with earthy sediment. To

* This characteristic of the Divine mind may be also, although perhaps somewhat irrelevantly, exemplified by the announcements of his moral laws, and his dealings with his own people, the Jews. Amongst innumerable instances which might be adduced, we shall only refer, at present, to the institution and the observance of the Sabbath. This hallowed day was ordained at first "for man," while he was in a state of perfect happiness in Paradise; and it may be well to observe, that it was distinguished by the *example* of Jehovah as well as by his beneficent *precept*. But even after man had miserably sinned and fallen away from this holy state of communion with God, when the manna was given to the murmuring Israelites in the desert, the sacredness of the sabbath was scrupulously preserved during the whole of the protracted period of the wanderings of that typical nation in the wilderness, by a provision as benignant as it was just, a double portion of the "angels' food" being bestowed and permitted to be gathered (contrary to the decree affecting the other five days) on Saturday; thus showing, that a moral statute, as well as a physical law, which has once been instituted, must, in all subsequent arrangements and decrees of the Divine will, be scrupulously respected. "Heaven and earth may pass away, but one jot or one tittle of the law shall not in any wise pass away, until all be fulfilled." Such is the conclusive announcement of him, who is the first and the last, the sovereign creator of the universe, and the saviour of his people.

the complete establishment of this position our argument in the present section will be exclusively dedicated.

We must again call to remembrance, that during the period to which we allude, the waters were maintained above the level of the spherical earth, by the centrifugal impetus which had been impressed upon them; and that they were in this state when the command was issued for the introduction into their midst of the principle of expansion. As the greater part of the last section has been dedicated to show the fitness, at that period, alike of the condition of the atmosphere, and of the waters of the ocean, for promoting rapid or almost instantaneous vaporization, we have only, now, to apply those truths to the case we are at present considering, in order to be convinced, that no arrangement could possibly have been better adapted for effecting the separation of the waters from off the continents, and from those lands whose height rose above the then lower limits of the atmosphere; or, what is the same thing, *above the present level of the ocean.*

Perhaps it may be as well to introduce, at this particular place, a conclusion which we came to when meditating on this part of our subject. We allude to the level for the surface of the waters, which was established on the formation of the firmament; or rather the probable level at which the firmament divided the waters from the waters. It was some time before we could bring our minds to a satisfactory conclusion on this point, in consequence of *blending the pressure which the atmosphere exerts on water with the question of its level.* But at length the conviction struck us, *that at whatever level the plane, formed by the under surface of the firmament, cut the primitive waters, those under it would not be subjected to more pressure than before: because there was no new matter (possessing gravity) willed into existence by the formation of the atmosphere, but merely a modification of what had previously existed;* and, consequently, as respects *condensation,* the waters which remained under the atmosphere had as great a pressure upon them *before* that event as they had *after* it took place. The subject, therefore, resolving itself into this—that, at first, the whole body of the waters tended towards the centre of the earth; but, in consequence of the formation of the firmament

from a certain level, a portion of them, and of the gaseous elements which were combined with them, having been united to the principle of expansion, were thereby induced so to expand or spread themselves out into space, as that their upper and under surfaces became about forty-five miles apart. Nevertheless, as the matter, comprised within these limits, still remained under its original law of gravity, *it continued to press on the waters beneath it, or those which remained uncombined with the subtile principle, with an aggregate weight precisely similar to what it did previous to its sudden enlargement of volume*—a conclusion directly based upon the mechanical axiom, "that the centrifugal force increases as the mass of the moving body increases."* For the earth, and all the matter it contained, having previously revolved for ages around the sun, there could not have been the slightest increment made to its mass, by additional matter having been created: otherwise its centrifugal force must have experienced a corresponding increase, and thereby have deranged its orbital movement in space, no corresponding aggregation having been made to the attractive influence of the sun around which it revolved.

Our argument especially enjoins on us, to distinguish with precision between the conditions of an atmosphere in the process of formation, and those of one actually constituted, as we now experience it. In the former case, that more immediately under our consideration, the elements of which it was being composed were in the act of emanating from the primeval ocean, and expanding themselves, with inconceivable rapidity and violence, into the regions of space, to the height of forty or fifty miles above their former level; and, consequently, they relieved the evaporating surface from all pressure: or, in other words, accelerated the combination of the expansive principle with the elements of water and their associated gases, by an accession of force equal, according to some estimates, to one hundred and twenty-four degrees of Fahrenheit's thermometer, and of one hundred and forty according to the opinion of others. Besides, it is one of the best established axioms of pneumatics, "That the elastic force of any given portion of

* Theorem 73.

air is augmented in precisely the same proportion as the space within which it is enclosed is diminished."* This announcement may assist us to conceive the irresistible violence and velocity with which the body of the atmosphere would rush upwards from its state of *greatest possible reduction of space*, which it maintained when, as yet, its elements were in their most condensed form, before the light was introduced, or the earth had been made to revolve around its axis, to assume *its tension of equilibrium*, the static condition in which it now remains! We can imagine nothing similar to this sudden and violent rush of gaseous elements upwards and around, except it be the rush of waters which took place from the poles towards the equator to complete *their* figure of equilibrium, or that of rotation, when the earth first revolved around its axis. In the latter case, centrifugal impetus alone occasioned their violent rushing motion. In that of the atmosphere, while the elements were assisted in their upward tendency, against the all-comprehensive law of gravity, by the centrifugal force then brought into action, the impartation to their ponderable bases of the buoyant principle of light, at the same time completed their impetus of ascension into the regions of space.

" Mariotte," says Dr. Thomson, as we have before quoted, " discovered the law of atmospheric elasticity to be, that the density or volume of a given quantity of air is inversely as the pressure."†

There is another important truth, derived from the study of meteorology, which it is essential should be borne in mind for the more thorough comprehension of our present argument; we allude to *the capability of the atmosphere to support, imbibe, or to become saturated with watery vapour*. This varies greatly *and increases rapidly according to the temperature;* indeed, so much is this the case, that Dr. Dalton found the amount and tension of vapour in the atmosphere to be altogether independent of the presence of the air, and to be wholly regulated by caloric. Dr. Thomson mentions a difference of range between 1-62nd and 1-80th of the volume of the

* Hydrostatics, Cab. Cyc. p. 237. † Introduction to Meteorology, p. 23.

air, but other writers give much greater extremes.* These will serve to show the amount of the agency which might be imposed upon the firmament to produce *vaporization*, and to bear up and transport the vapour, especially when the former was in process of formation, and while as yet it exercised *a comparatively light pressure upon the evaporating surface, and was, itself, of a high temperature.* The drier the atmosphere is, the greater is its influence in promoting evaporation from moist surfaces.

Keeping, therefore, these preliminary observations properly before the mind, let us endeavour to apply them to the elucidation of our present point, namely, *the vaporization of the water from off the surface of the land, and its transference, by means of the new formed atmosphere, into the waters of the ocean;* our assumption being, that the atmosphere, called in Genesis "*the Heavens*," was the appointed means whereby the Creator effected his purpose, without exposing the land to any of those prejudicial effects which, according to the laws of matter, would have ensued, had this ubiquous agent not been employed *to raise the water off the surface of the earth designed to become "the dry land";* while as yet the upper part was in process of being formed into ferracious soil by the oxidation of the elements then present, and the comminution of the rocky masses brought into collision and abraded by the recent commotion, consequent on the protorotation of the earth; while the same aerial agency was employed to waft away the surplus water, and to deposit it wheresoever the Almighty chose to determine, when He gave forth His command, "Let the waters under the Heaven be gathered into one place (the seas), and let the dry land appear."

We can easily conceive how absolutely essential such agency as this was to effect the double purpose of raising the water *off* the ground, in order that it might be rendered innoxious,

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* Mr. Hutchinson says from 1-60th to 1-300th part, and in warm climates nearly double; and Professor Whewell considers that the proportion, in weight, which the *aqueous* bears to the *aerial* portions of the atmosphere, may vary according to circumstances from 1-100th to 1-20th of the whole aerial ocean. (Bridgewater Treatise, pp. 96—99). See also Philosophy of Storms.

and do no injury by denuding the land during its removal; while at the same time it was being carried most effectually, by the newly formed and most heated part of the atmosphere, to regions perpendicular to those hollows "destined from everlasting" to be the receptacles of the world's wide oceans! There is something peculiarly sublime in the conception of operations so vast as these being effected by means so simply comprehensive and so effectual!

The glorious atmosphere, fresh from the hands of its Creator, and ere it was polluted by the breath of a single mortal, hastening, in obedience to the commands of its God, to be the willing, the powerful, and the effectual instrument of His designs in forwarding the progressive development of His plan of creation! No sooner is it fully formed, than it aids the completion of other portions of the great work; draws up the surplus waters with inconceivable rapidity; separates them, by infiltration as it were, from their saline associates, which were required where they had been thrown by the general revolution; and hurries the disassociated waters along through thin aerial space, to let them drop where *they, too,* are required, in freshness and separation from their formerly commingled salts!

It may be well here to observe, merely as a memorandum to be afterwards referred to, that up to that period of the creation to which we now allude, there was no motion which, strictly speaking, may be considered *lateral motion.* Hitherto we have only had to consider motion either from the centre towards the circumference or from the circumference towards the centre. *Lateral* motion seems to have commenced with the command—"Let the waters be *gathered* together into one place." And well may the seas of the whole world be said to have been gathered into "one place." For however corrugated and diversified may be their *littoral* and their *under* surfaces, yet their *upper* surface shows, by having found and maintained a common level, "that the waters under the heavens" have all commingled, and that they occupy "one place."

In prosecution of the main, or more direct line of our discourse, we must now seek to make our readers acquainted with

what is stated in the *eighty-fourth* Theorem respecting the upper boundary or limit of the atmosphere, "*whose density diminishes with extreme rapidity as it proceeds upwards, and, eventually at a height, not exceeding fifty miles, reaches a real and definite boundary,*" *where there is no atmosphere.* "*And that this upper surface is estimated to be precisely where the specific elasticity of the air is balanced by the power of gravitation.*"

By this theorem we are informed, that the atmosphere has a definite boundary upwards; and we know, likewise, that the earth and oceans form its bed or margin underneath, consequently it follows, as a clear deduction, that whatever may have been the force or rapidity of its expansion when in the process of formation, of whose direction we have already been made aware, and which, owing to the inflexible nature of the materials constituting its lower bounding lines, *must have been upwards.* Taking, therefore, these into account, we cannot fail to be convinced, that whenever it had reached that point of static equilibrium, "where the specific elasticity of the air" became "balanced by the power of gravitation," *there must have ensued an immediate revulsion equal to the whole weight of the atmosphere.* So long as the atmosphere was expanding laterally and also rushing upwards, *there could have been no pressure whatever on the waters beneath;* but so soon as that upward and lateral tendency ceased, an opposite tendency on the part of the atmosphere, as a whole, must, in obedience to the previously existing laws of matter, have taken place. This may be expressed in other and perhaps more perspicuous terms by saying—that during the process of formation, the *ponderable* bases of the atmosphere, from the very fact of their being in the act of combining with the principle of expansion, were necessarily abstracted from the antagonistic force of attraction, until they had attained their static condition of buoyancy; and in this combined state were restored to the influence of attraction: the minute particles of ponderable matter constituting the radicle or base, remaining in immutable combination with the elastic principle of light; but, as a whole, recognizing at the same time the law of gravity in precise proportion to the entire mass. This is expressed by Dr. Thomson (as already quoted) in the following words—

"Believing that the atmosphere is composed of ultimate atoms, it is evident that a limit does exist; for the force of gravity, drawing each towards the earth's centre, must be greater than the repulsive power of the individual particles in proportion to their density, and exactly where their forces balance the extreme boundary will be found."

Proceeding on the assumption which we have made, that the surplus water was transferred from the "land" to the "sea" by *vaporization*, through the instrumentality of the recently formed atmosphere, we remind our readers that they have been made aware of the extraordinary range of degrees to which the latter can be saturated with watery vapour, even from one-hundredth to a twentieth part in weight according to Professor Whewell. Further we have to assume, as a matter of course, that on the occasion in question, when the atmosphere was employed to perform this operation, it was impregnated with moisture to its utmost capability. This position, we presume, will be readily conceded. But the transference of watery vapour from *underneath* the level of the atmosphere into the atmosphere itself, that it might become its carrier; or what is the same thing, the loading of the atmosphere with a super-degree of watery vapour, to the extreme of what it would carry, is tantamount to the transference of ponderable matter from *beneath* the level of the atmosphere to a line *above* that level; and, consequently, is equivalent to the exertion of a pressure by the atmosphere on the waters, corresponding to its increase of gravity.

It will at once be perceived how conducive this pressure would be in forwarding the due development of the plan of creation, at the very point then in progress, inasmuch as it would contribute to restrain the oceans within the limits assigned to them; and by pressure make room for the very waters which were to be added to the seas, when that which existed as surplus vapour in the loaded atmosphere should be condensed into rain and added to the great oceanic mass. The description given by the Creator of that event, when speaking by the voice of another of His inspired historians, is so remarkable, and verifies so completely the opinion we have

formed, that we quote the passage with much satisfaction, as corroborative evidence:—

"*Who*," asks the Omnipotent of his afflicted but patient servant, "shut up the sea with doors, when it brake forth *as if* it had issued out of the womb? When I made the cloud the garment thereof, and thick darkness a swaddling band for it, And brake up for it my decreed *place*, and set bars and doors, And said, Hitherto shalt thou come, but no further; and here shall thy proud waves be stayed?"*

Now, it is assumed—on the principle, "that matter can produce no spontaneous change, either in character or motion in itself"—an axiom often referred to in this treatise—that when the firmament or atmosphere had once reached a static condition of equilibrium; and that condition it was certain to assume in fulfilment of the laws conferred on its material nature, it could not of itself have changed in one iota; nor would the work of creation have been advanced a single degree further, unless it had pleased the Omnipotent to have, as we are informed by the inspired historian, at this very juncture, issued a new decree, whereby the work was caused to progress. And when we take into consideration the state of creation at the period referred to, we shall find that it was the decree most essential, nay absolutely indispensable, agreeably to the general laws of matter and the particular condition of it, alluded to above; we mean its incapability of spontaneously producing alteration in itself. Hitherto there had been no *lateral* motion impressed on matter; its movements had been produced by either attraction towards the centre, or by centrifugal impetus *from* the centre towards the circumference; or by a composition of those two forces, as in the case of the lunisolar current around the earth in the midst of the primeval circumfluent waters. While in the case under immediate consideration, if there had been no *new* command given; the waters which rose by vaporization from off the land and from intermixture with their former earthy and saline associates, would necessarily have fallen in the condition of rain—abundant rain, back again upon precisely the same spot from whence they arose; and would have entered into recombina-

* Job xxxviii. 8—11.

tion with the materials from which they had been, for wise purposes, disassociated. When we consider, too, the media into which this lateral movement was first introduced—*the atmosphere*—a body abstracted almost, as it were, from the influence of friction, we shall more fully recognize the wisdom of the approaching decree—"Let the waters *under* the heaven be gathered into one place, and let the dry *land* appear." Every concomitant circumstance having been, by the previous arrangements, made to be in favour of the easy fulfilment of this command; whilst at the same time the *atmosphere*, or "Heaven," was formed that it might be the chief instrument of its execution.

We wish it to be particularly observed, that it was not until the "*firmament*" had been so far completed as to have been called "*Heaven*," that it was thus employed to transfer the water from off the land—"Let the waters *under the Heaven* be gathered together." This is a very important circumstance, and should be taken notice of. It was not the water, which was merely in the degree of combination of the *firmament* with the buoyant principle of light, which was to be thus concentrated, but that which, *under* the degree of combination of the "*Heaven*," which was ordained to be "gathered together into one place;" or, in other words, what the firmament, when completed to its average saturation with watery vapour, was not destined to retain *in a fluid or vaporous condition;* in short, that portion which, amidst many meteorological vicissitudes, had reached, what writers on this branch of science call undersaturation, and which would, on all occasions thereafter, in some form, or at some time and place, by the imposition of this law, be restored to the liquid condition of water, and, by means of rivers, lakes, &c., when the earth had, in the meanwhile, been properly prepared for it, and which was thereby to be united to the general aqueous portions of the earth's surface.

As exemplifications of this we may quote the following apposite passages from recent writers on meteorology:—

"When the dryness of the atmosphere is mentioned," says Mr. Hutchinson, "reference is made, not to the absolute amount of

moisture in the air, but to the amount in relation to its capacity. The more under-saturated the atmosphere is, the drier it is said to be; and the stronger is its influence in promoting evaporation from moist surfaces. On the contrary, the nearer it approaches to saturation, the more humid it is, and the less its influence in promoting evaporation.

"During night, the capacity of the atmosphere for moisture, in consequence of the diminution of temperature which then ensues, is considerably less than during day. . . . . And provided it reaches the point of saturation previous to the coldest period of the night, the farther sinking of temperature causes precipitation of moisture into the visible forms of dew, mist, and cloud. . . . . .

"It may be noticed, that when speaking of air becoming under-saturated in consequence of passing over extensive tracts of land, it supposes a large proportion of its surface to be dry. When the surface of the land is thoroughly wet, ... and is warmer than that of the ocean, as is sometimes the case, evaporation from its surface should go on more rapidly than from that of the ocean, ... whose saline ingredients render its waters less liable to evaporation,"* and so forth.

"When the air near the surface of the earth," observes Mr. Espy, "becomes more heated, or more highly charged with aqueous vapour, which is only 5-8ths the specific gravity of atmospheric air, its equilibrium is unstable, and upmoving columns or streams will be formed. As these columns rise, their upper parts will come under less pressure, and the air will therefore expand; as it expands it will grow colder about one degree and a quarter for every hundred yards of its ascent, as is demonstrated by experiments on the nephelescope. The ascending columns will carry with them the aqueous vapour which they contain, and if they rise high enough, the cold produced by expansion from diminished pressure will condense some of the vapour into clouds; for it is known that clouds are formed in the receiver of an air pump when the air is suddenly withdrawn. The height to which the air will have to ascend before it be cold enough to form clouds is a variable quantity, depending on the number of degrees which the dew point is below the temperature of the air; . . . . and the difference between the dew point and the temperature of the air is called the complement of the dew point."†

* Principles of Meteorology, Hutchinson, pp. 17, 21, 27.

† Philosophy of Storms, Synopsis, Introduction, pp. viii. ix.

Dr. Thomson informs us, that

"Dalton has demonstrated, that the elasticity of water at the boiling point, under mean pressure, and that of our atmosphere at the same pressure, are equal; that aqueous vapour possesses exactly the same repulsive force in the atmosphere which it assumes in a vacuum, the temperature being the same; and that as its elasticity depends upon the increase of heat, so it is possible to ascertain the amount of vapour floating in the air, at any temperature, by measuring the elasticity of the aerial fluid. . . . . . He reasoned upon evaporation as we do on the *inertia* of matter, and by experimental research discovered in it a conformity with the laws of mechanics. . . . . . The diffusion of aqueous vapour in the atmosphere is what is meant by its humidity; . . . . . the specific gravity of a humid atmosphere being lower than that of dry air; because vapour is lighter than air, bulk for bulk, it follows, that the specific gravity of the atmosphere is subject to its humidity. Hence the amount of moisture present may be ascertained by the weight of a cubic foot, keeping in mind, however, that a cubic foot of such an atmosphere consists of a cubic foot of dry air, and a cubic foot of aqueous moisture, filling the same 1,728 inches, and having a tension proportioned to the temperature.

"The quantity of vapour exhaled is greater when the surface is extensive, and this in proportion to the superficies. It is computed, that the evaporation from a square degree of ocean exceeds 33 millions of tons daily, and that consequently, the Mediterranean, alone, daily loses, in this way, 5,280,000,000 tons of vapour.

"Evaporation goes on less speedily in moist than in dry air, and in cold than in warm temperatures. . . . . . A given volume of air contains more vapour in the tropics than in the polar regions."

And again—

"A current or high wind, by disturbing the equilibrium of the molecules of the air, promotes evaporation. . . . . . Professor Daniel has shown that, as the pressure of the atmosphere upon a fluid is reduced by an arithmetical progression, the loss of heat by evaporation follows in a geometrical series, and the amount of evaporation is increased. . . . . . By a wise arrangement of nature, however, a check is given in the surrounding atmosphere to the descent of the thermometer during the process of evaporation. . . . . As extreme instances of the frigorific power of speedy evaporation, we would refer to the solidification of carbonic acid gas, and to

Boutigny's beautiful experiment of freezing water in an incandescent crucible."

In conclusion from this writer—

"The temperature denominated *dew-point*, is that which represents the point at which vapour is deposited upon any object colder than itself. When the dew-point and the atmospheric temperature are the same, the amount of moisture floating in the air is at its maximum, but this does not often occur, the atmosphere being generally a few degrees warmer than the dew-point. . . . . . The difference between the dew-point and mean diurnal, mensual, or annual temperature is the *mean dryness* of the same respective period. The *mean dew-point* is always below that of mean temperature.". . . . .

And lastly—

"The question whether aqueous vapour is chemically combined or merely blended with the atmosphere, has not been determined; Berzelius, Berthollet, Saussure, and Thomson support the former theory, Dalton, Henry, and Author, the latter."*

Unless a law which should have the effect of producing the results thus designated had been promulgated, and at this juncture, whereby the surplus watery vapour which the atmosphere had taken up, in its amazing stretch or elasticity, had been made capable of forming itself, or being formed into clouds, and being thereby borne along upon the atmosphere, we cannot conceive the "firmament" or "Heaven," to have been otherwise than one dense and misty mass of vapour surmounting the land and seas, without presenting to the bewildered eyes of man or of animals any distinct line of separation between the ocean and the atmosphere. But such imperfection as this is inconsistent alike with the benignity and the wisdom of the Creator, and hence we have the effectual and well-timed decree—"Let the waters under the Heaven be gathered together into one place, and let the dry land appear;" while the mere fact of having put on record an announcement

* Introduction to Meteorology, pp. 97—107; and upon the authority of numerous writers quoted by Dr. Thomson.

so remarkable, and with reference to so critical a juncture, tends to confirm the assertion we have so frequently before made, that the inspired historian derived his knowledge from a superhuman source. Its conformity with the laws, which govern this particular branch of natural philosophy, can be established by only the *latest advances* in this department of scientific research; and, therefore, it is not at all probable, that any merely human forethought could, so many thousand years ago, have revealed these natural arcanæ to the author of this part of Scripture. This is by far too conclusive to require any further illustration.

An equally undeniable argument is supposed to be deducible *from the level at which the Firmament or Expansion* was originally placed in the midst of the primeval waters. In working out this, we shall not occupy our time unnecessarily in refuting any arguments which may be founded on the untenable assumption, that the lower surface of this aerial body might have been struck at a level *above the summits of the continental mountain ranges*, when they at first arose from their recumbency on the spherical earth, for, besides the numerous inconsistencies which this would necessarily imply, the advocates of any such opinion, which involves the inference, that the atmosphere sank down gradually until it assumed its present level on the surface of the collected waters, have to account for the difference of aggregate gravity, between what it must have had, in that supposed case, as a hollow aerial sphere of infinitely greater magnitude, compared with that which it now has, embracing a comparatively reduced circle, which is traced out by its present under boundary line, the surface of the oceans and the land.

But leaving such comparatively trivial questions to one side, we shall assume, upon the most substantial data, *that the primary lower level of the atmosphere over the oceanic portion of the earth's surface was*, with the slight difference of the increment occasioned by the water transfused into the ocean by the instrumentality of the atmosphere itself, *that which at present it occupies*. This, it is obvious, must have been then, as it still is in many places, upwards of twenty, and in some instances even as much as twenty-seven thousand feet beneath the sum-

mit of the mountains; for, as the *eighty-fourth* Theorem expresses it:—"*The atmosphere is an aerial ocean surrounding the earth in all directions, and of which the surface of the land and sea forms the bed.*" We know that there are mountain ranges of this height which, although then but recently elevated, yet existed at their present elevation *before* the atmosphere was formed, and which now penetrate *upwards*, if we may so express it, from twenty to twenty-seven thousand feet *into* the aerial ocean in question: just as there are, on the other hand, oceanic hollows into which the waters penetrate many thousands of feet below the undermost aerial surface.

The admission of this fact, which is apparent to the *senses*, and subject to actual measurement, seems to bring us into immediate collision with another equally well authenticated fact, although it may not be so perceptible to the eye of sense, namely, that notwithstanding this great elevation of the mountain chains above the *undermost* level of the *atmosphere* there was no land discernible; or rather, there would have been no land discernible at that time had there been mortal eyes to have searched for it. It was still enveloped by the primitive waters and by their vaporous exhalations in the atmosphere, even after this had been completed, until the command went forth—"Let the waters under the heaven be gathered together into one place, and let the dry *land* appear."

The seeming opposition of these two branches of evidence, neither of which can be disputed, appears to involve our argument in so serious a difficulty, as almost to bring it to an abrupt conclusion. For, on the one hand, we have considered that there was an atmosphere which already divided waters which were *above* it from those which were *under* it, stretching as we admit it to have done, from nearly the same *lower* level which at present it maintains on the bosom of the oceans, with entire continental chains of great collective elevation, and mountains towering even beyond these, all previously raised in solid stability; and yet, on the other hand, we are constrained, from our implicit confidence in the announcements of *the only* authentic evidence to be found coeval with that period of the earth's history, to maintain, as we most assuredly do maintain—*That not one of all those immense masses of mineral*

material, thrown up by the protorotation of the world, was at all discernible, nor could have been perceptible to the keenest human vision, had there then been a mortal eye in creation to have beheld them.

Now, it is precisely that which threatens to put so abrupt a termination to the progress of our argument, that we intend to make our chief means of proving the assumption we are at present contending for, namely, *That the waters were separated by vaporization from the land by means of the new formed atmosphere.* For, if after this latter part of the creation had been finished, there had been underneath it only an unbroken expanse of oceanic waters; then, we confess, we should have been placed in a dilemma from which no human ingenuity or powers of reasoning could, by any means, have extricated us; but the circumstance of the lower level of the atmosphere having been so many thousands of feet below some portions of the land, even when this was obscured by it, has left undeniable evidences, written in characters which can neither be misunderstood nor unattended to, *that the surplus waters were evaporated from off the land, inasmuch as they have left a residium behind them which the atmosphere could not carry away with it;* but *which would not have remained, if "the waters,"* which were removed to admit of the "dry land" appearing, had *been drained from it into the oceanic hollows.* Fortunately, in favour of this we have a body of evidence so strong, and so directly based on scientific research, and a chain of reasoning so complete, that nothing can withstand their combined influence.

The first point to which we shall direct the attention, is part of what is contained in the *ninety-fifth* Theorem, especially in its latter clause:—"*That, in general, the rate of evaporation from the surface of the water, in all states of the atmosphere, will be proportioned to the tension of vapour which would saturate the atmosphere, diminished by the tension of the vapour actually in the atmosphere. And that, as different substances are subject to vaporization at different temperatures, this peculiarity is frequently employed in chemistry and the arts, as an efficacious method of precipitating solutions by separating them from the water with which they are combined.*"

As we have already adduced many evidences in support of the first part of this theorem, we design at present to exemplify, more particularly, its concluding portion, by the following apposite quotations from the scientific writers on whose *dicta* it is based:—

"Water," says Dr. Thomson, "at all temperatures, assumes the form of vapour. Evaporation proceeds from the snow-clad mountain and the glacier, as well as from the ocean and the meadow. Evaporation differs from vaporization in the amount of heat required for its production. Water *vaporizes* when it passes into *steam* at a temperature of 212°; below that temperature it *evaporates*, passing into the ambient air in insensible moisture. . . . . . Besides other truths, Dalton has demonstrated that the elasticity of water at the boiling point under mean pressure, and that of our atmosphere at the same pressure, are equal; that aqueous vapour possesses exactly the same repulsive force in the atmosphere which it assumes in a vacuum, its temperature being the same,"* and so forth.

"If," observes Mr. Reid, "a few fragments of caustic potash be exposed to the air for a short time, they will become moist, softened, and liquid, in consequence of the moisture which they absorb from the air. . . . . . If the potash, thus melted be heated strongly, the water may be boiled off, when the potash will be found in its former condition, dry, hard, and solid. Common pearlash, or the substance called chloride of calcium, may be used instead; a similar effect will be produced. . . . . . The chief cause of the presence of watery vapour in the air is the influence of heat, which, acting on the water of the seas, lakes, and rivers, in the world, is continually infusing the repulsive principle into them, and converting part of their surface water into vapour."†

"By such means," Dr. Lardner concludes, "the quantities of heat necessary to raise different bodies through the same range of temperature may be compared; and such a comparison presents the remarkable fact,"—which has been extensively availed of in the arts and manufactures to separate one substance from another—"*that every different body requires a different quantity of heat, to produce in it the same change of temperature.*"‡

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* Introduction to Meteorology, p. 97.

† Chemistry, by Hugo Reid, pp. 53, 54.

‡ Heat, in Cab. Cyc. pp. 243, 263.

As we shall almost immediately have occasion, in the prosecution of our argument, to bring forward proofs on a subject intimately connected with the *ninety-fifth* Theorem, whose evidences unavoidably blend together, we take the liberty of referring our readers to what may then be adduced, in addition to what has just been said; and trust, the whole will be sufficiently explanatory and satisfactory: indeed, the every day operations of our households teach us the different capacities for heat of water and of solids; this principle being invariably acted upon, although perhaps not chemically or scientifically understood.

The next thing to be done, is to bring the general truth, which has just been proven, to bear more closely upon the point desired to be established. For this purpose we bring forward the conclusion given in the *fifty-eighth* Theorem:—"*That if heat be applied to a solution of salt and water, the repulsive force will cause the atoms of water to separate from the atoms of salt and carry the former away in pure vapour, while the salt will remain in the form of crystals; the same degree of repulsive force not being capable of overcoming the natural cohesion between its particles. That precisely similar results will ensue if a solution of the same material be exposed to vaporization; which, if continued for a sufficient length of time, will cause the water to disappear altogether, and leave a crystalline mass of salt behind.*"

As the evidences of this theorem are essential, we give them somewhat in detail:—

"The great reservoir of water," observes Mr. H. Reid, "from which all other kinds of water are, in the first instance derived, is the ocean, an almost inexhaustible supply, when we consider that it covers about three-fourths of the entire surface of the globe. In what way, it will be asked, can the water of rivers, lakes, springs, &c., be derived from the ocean? How is the salt water of the ocean converted into fresh water? The water of the ocean consists of a large quantity of common salt, and a few other matters. Now the water (*the pure water* consisting solely of oxygen and hydrogen) is very readily turned into vapour, even at the ordinary temperature of the air, and very abundantly in warm weather; while the salt and the other matters, having a different relation to heat, do not readily

pass into vapour, even at the highest temperature in the torrid zone. *Thus, the pure watery part of the ocean is turned into vapour and passes into the atmosphere, the salt and other matters being left behind; the sea water being thus decomposed by the effects of heat upon it. . . . .* In order to procure water from any common spring or river water, there are two kinds of substances which must be got rid of before it is chemically pure, the gaseous matters which it contains, and the earthy matters. . . . . . But the earthy matters are separated in a different manner; the water is obtained free from them by the process of *distillation*. After the water has been boiled to expel all the gases which it may have contained, we continue to boil it, but cause the vapour or steam which comes away from it to pass into another vessel, in which it returns to the state of water. The heat applied to turn the water into vapour cannot convert into vapour the earthy matters which the water holds in solution; they remain behind, and are thus got rid of. The next vapours which come away are collected and condensed; they are the pure watery part. A little of the water (one-fourth) is left in the vessel along with the earthy matters, and it will be seen that this water which remains behind is somewhat opaque and muddy, or at least not so clear and pellucid as the water condensed from the steam."*

According to the principles of heat in Cabinet Cyclopedia—

"If salt be dissolved in water a chemical combination will be formed, and the molecules of the compound will be composed of atoms of salt combined with atoms of water, these being held together by the force of their affinity, and thus forming the molecules of the mixture. Let such a solution be placed in a glass vessel B, closed at the top, and terminating in a tube which is carried to another vessel D, immersed in cold water. If heat be applied to the vessel B, sufficient to boil the solution contained in it, it will be found that the vapour produced will pass through the tube C, and will be condensed into a liquid in the vessel D. After this process has been continued for a certain length of time, it will be found that nothing but solid crystals of salt will remain in the vessel B, and the liquid contained in the vessel D will be pure water. If the masses of water and salt in the two vessels be weighed, their weights, taken together, will be precisely the weight of the solution first placed in the vessel B. . . . . . A small quantity of salt of any kind dis-

* Popular Treatise on Chemistry, pp. 115, 116, 131.

solved in water causes the boiling point to rise higher than that of pure water. The steam, therefore, of such a solution, at the same temperature, would have a less degree of elasticity than the steam of pure water; and this is found to be the case. Now it is a curious circumstance that this steam does not contain a single particle of the salt dissolved in the water, nor any substance but pure water itself, which may be made manifest by carrying it off, and condensing it in a separate vessel. . . . . . Evaporation being extensively used in the arts and manufactures, it has become a matter of considerable importance to conduct it with as much economy and expedition as possible, the circumstances which principally promote it, being increase of temperature, and a constant change in the air which is immediately above the evaporating surface. These two objects have received special attention. In factories, where evaporation is used, the vessels containing the liquid to be evaporated are usually placed where they shall be exposed to a current of air passing over their surface. In cases where it has been found convenient to promote the evaporation by heating the liquid, the heat is frequently applied only to the surface, instead of being communicated by fire at the bottom of the vessel. In fact, the current of air which is made to pass over the surface of the evaporating liquid is previously heated by forcing it through a fire. The flame of the fire is also sometimes made to play over the evaporating surface."*

"The facility," says Mr. Donovan, "with which bodies assume the crystalline form is very various; some doing so with great ease, and others with great difficulty. The general method of obtaining crystals from substances which dissolve in water is to add the substance to the water at a boiling heat, and in as great a quantity as the water is capable of holding in solution. As the liquor cools, the crystals are produced; and the more slowly it cools the more regular the crystals. Sometimes it will be necessary to reduce the liquor to the freezing point before it will crystallize; and sometimes it will show no more tendency to do so when cold than when hot; in which case the water should be gradually boiled away until the crystals have formed abundantly; it is in this way that common sea salt is crystallized. Motion promotes crystallization; but rest promotes regularity of the shape of the crystals."†

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* Dr. Lardner, pp. 193, 207, 243, 244.

† Chemistry, in Cab. Cyc. pp. 18, 19.

In continuation of the same chain of evidence, it will be necessary to ascertain what takes place when water, holding in solution the elements of *various descriptions* of salt, is subjected to the influence of evaporation. And it is satisfactory to find, that this and kindred subjects have received the closest attention from several chemists of the present day, on whose enquiries and chemical acumen we may safely place every reliance. While it may not be out of place nor uninfluential on our subsequent reasoning, were we to bear in mind, that when saline materials are held in combination by water, holding also earthy ingredients in suspension, and deposition takes place, the salts are found invariably to crystallize almost in purity and separation from their associated elements; and to leave these to accumulate at the bottom, according as their specific gravities, or other attendant circumstances, may determine.

"It is," observes Mr. Reid, "from its property of dissolving solid bodies, that water has the greatest claims on our attention. Various bodies, when dissolved, manifest properties which we should never otherwise have been able to discover they were possessed of. Although water has a chemical attraction for a great many bodies, it has seldom a very strong attraction for them, and therefore does not alter their properties much, and seldom retains them with such a force as to prevent other bodies, which may have any affinity for them, from acting upon them.

"It may," he continues, "be observed in the operation of solution, which is frequently performed for the purpose of *separating one substance from another, or from a number of others with which it may be associated.* Thus, the barilla from which soda is procured, contains the soda mixed with a quantity of other matters. The soda, however, is very soluble, while the others are insoluble, or nearly so; by lixiviation, then, the soda is extracted in solution, and the other matters are left in the solid state. The soda, however, has not a very great affinity for water, so that the latter readily leaves it in the form of vapour when heat is applied, and thus the soda is procured in the solid form. Water and heat are applied in this way to separate from each other various matters which may be mixed together, in a great many manufacturing processes, and many of the

most useful articles which are used by man could not be procured without some such operation."*

"Besides the methods," says Dr. Murray, "of discovering the saline ingredients in mineral waters by re-agents which indicate their principles, they may, by certain methods, be obtained in their entire state, and their quantities determined. Evaporation is employed with this view, different substances being successively obtained as the evaporation is carried to a greater or less extent. Thus the carbonates of lime and magnesia are usually first precipitated, afterwards sulphate of lime falls down; if after these precipitations the liquor be drawn off and allowed to cool, the alkaline neutral salts and the sulphate of magnesia crystallize, while muriate of magnesia and muriate of lime, if present, will remain, forming an uncrystallizable residue."†

Having thus briefly shown, that which usually takes place when water holding in solution *the elementary principles of salts* (without having taken into account the destiny of the earthy parts which may have been held simultaneously in mechanical suspension) is subjected to vaporization, we shall now endeavour to show that, when salts, by crystallizing, separate from their earthy associates, the latter fall down or are deposited in layers according to their specific gravities, or other attendant circumstances, or, in other words, in the inverse proportion of the power of the aqueous body to sustain them in suspension.

The following extracts, a part only of those which might be given, have reference to this subject:—

"Much of what goes on in the sea," observes Professor Phillips, "is entirely unknown to us. . . . . . How far into the sea currents of given velocity may transport sedimentary grains of given magnitude and specific gravity, is matter of calculation, (Babbage); how far, in fact, the supernatant fresh waters can carry their earthy admixture, has been, in one instance, ascertained, (River Amazon, Captain Sabine), ... but still it is to the shores that we must

* Popular Chemistry, pp. 109—111.

† Murray's Elements of Chemistry, vol. ii. p. 385.

ever turn for data to serve as bases for comparison between modern and ancient marine deposits.

"Here we see that the materials which the sea obtains from the wasting cliffs, rivers, and floods, are partly transported away by currents, and especially during storms, to considerable distances, but principally drifted coastways, and deposited in times of tranquillity. . . . . . In distributing the materials which fall from the cliffs, the agitation of the sea produces an effect of the same kind as the operation of washing a mixture of metallic ores and various spars, it separates the ingredients according to magnitude and specific weight; the heavy and large masses are left on the beach for slow distribution over the sloping surface or gradual descent into the deep; the coarse sand is urged onward by the tide, as a river pushes forward its bed, but the finer clays mix with the water, remain long suspended, and are carried to great distances, to be deposited wherever the sea stagnates, either by expansion, over level surfaces, or by opposition of the freshes.

"It is evident that the modern deposits of the sea are pebbly where the agitation is great, sandy where it is moderate, and argillaceous where it is little."*

"If," observes Mr. Lyell, in a passage already referred to in another part of this work, "we take a handful of quartzose sand, mixed with mica, and throw it into a clear running stream, we see the material immediately sorted by the water, the grains of quartz falling almost immediately to the bottom, while the plates of mica take much longer time to reach it, and are carried farther down the stream. At the first instant the waters are turbid, but immediately afterwards the flat surfaces of the plates of mica are seen alone reflecting a silvery light, and they descend slowly, to form a distinct micaceous lamina. It is easy, therefore, to conceive how the intermittent action of waves, currents, and tides may sort the sediments brought down from the waste of a granitic country, and throw down the mica, layer after layer, separately from the mud or sand."†

"The existence of the great and extensive operations," Prof. Playfair observes, "by which the spoils of the land are carried all over the ocean, and spread out on the bottom of it, may be supposed to require some further elucidation. We must attend, therefore, to

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* Treatise on Geology, pp. 202, 203.

† Elements of Geology, vol. i. pp. 31, 32.

the following circumstances. When the detritus of the land is delivered by the rivers into the sea, the heaviest part is deposited first, and the lighter are carried to a greater distance from the shore. . . . . . These are more easily carried to greater distances by being suspended in the water, from which they are gradually and slowly deposited. A remarkable proof of this is furnished from an observation made by Lord Mulgrave, in his voyage to the North Pole. About 250 miles off the coast of Norway he sounded with a line of 4,098 feet, and the lead, when it struck the ground, sunk in a soft blue clay to the depth of ten feet. The tenuity and fineness of the mud, which allowed the lead to sink so deep into it, must have resulted from the deposition of the lighter kinds of earth, which, being suspended in the water, had been carried to a great distance, and were now, without doubt, forming a regular stratum at the bottom of the sea."

In continuation, he observes, with his accustomed propriety of style—

"Amid all the revolutions of the globe, the economy of nature has been uniform in this as well as in every other respect, and its laws are the only things that have resisted the general movement. The rivers and the rocks, the seas and the continents, have been changed in all their parts; but the laws which direct these mutations, and the rules to which they are subject, have remained invariably the same."*

Having thus traced, by these progressive steps, the changes which take place when, by vaporization, water is driven off and separated from whatever earthy or saline ingredients it may have been associated with; and, in continuation, shown how the earths, clays, and other mineral materials are deposited from water, when borne by it in mechanical suspension: both of which circumstances of condition it is considered took place during the first three days of the earth's rotation, when the rushing agitated ocean was plentifully charged with saline material and with earthy debris; we may now consider ourselves in a position to proceed with the general argument; and we shall do so, accordingly, in the succeeding chapter.

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* Playfair's Works, vol. i. pp. 407—415, Huttonian Theory.

SECTION VIII.

COMPLETION OF THE ATMOSPHERE, &c.

CHAPTER XXXIII.

Opening advertency. During the juncture of protorotation immense masses of mineral *debris* mixed with saline materials spread abroad, and separated, within a few hours, from the water which held them in suspension. The Dynamical Theory requires that this separation should have taken place by VAPORIZATION. This fully borne out by the deposits of native salts, and confirmed by geological evidences, especially those having reference to the saliferous and gypseous associates of the New Red Sandstone and Oolitic formations. In continuation: several advertencies as to the way in which are to be viewed the operations then taking place; their order of sequence; the description of *forces* which prevailed; and the order in which they, too, were introduced into the universe. Indispensable utility of *lateral* motion in the formation of clouds, or in "gathering together" the nephalic masses of the atmosphere. And in conclusion, scientific proofs.

WE shall now endeavour to apply these detached, but requisite investigations, which have almost exclusively occupied our attention in the preceding chapter, in furtherance of the principal argument. Before doing so, however, it is requested, that what we have stated at the conclusion of the twelfth and commencement of the thirteenth chapters, relating to saline and acidulous ingredients held in solution by the primeval water towards the close of the non-rotatory period; together with that portion of the sixth section which treats of the New Red Sandstone formations, may be each carefully re-perused; they will be found to be intimately connected with our present subject, and essential to its development. Considering these suggestions to have been complied with, we beg our

readers' attention to the prefatory reasoning contained in the following brief argument.

During the elevation of the continents, an immense body of heterogeneous *debris* was spread abroad, and mechanically diffused throughout the surrounding waters which held saline and acidulous ingredients in chemical solution; and these waters thus saturated were, within twenty-four hours thereafter, separated from the land; an operation which must have been effected either by *draining off* the water, or by *vaporization*, natural means in either case having been permitted to operate. Under such combination of circumstances, we require to know, what would have been the probable results of the process by each of these two distinct methods of separation? And which is most accordant with the appreciable results remaining to the present day?

On the supposition of its having been effected by *drainage*, it is conceived, Firstly. That it could not have been accomplished *within the time specified*, by any natural means which are now known; Secondly. That both the earthy and the saline materials would have been simultaneously swept into the bed of the ocean; and, Thirdly. That there would have remained no saline or gypseous deposits of any extent. For, presuming the land to have had the same form which it now has, wherever the nature of the ground had impeded the escape of the saline waters requisite to have formed the deposits, the drainage of the present times would still have constituted lakes and reservoirs of water, and consequently no dry residium could have been formed; and therefore could not now exist.

But, on the other hand, it is conceived, that if *vaporization* was employed to separate the heterogeneous mass of water, earths, and salts from each other, and the like laws, which are still in operation, operated *then*, their precipitated remains should be found associated together, according to the manner in which such combined ingredients usually separate when they are being deposited. That although the rapidity, with which the vaporization was effected, might have prevented them, when finding a common level, from having assumed a perfect horizontality of position, they should, in general, be

found pretty near a level, stretching over plains, at the bottoms of hills, and filling up hollows. That in obedience to the laws affecting the application of heat to a solution, in order to occasion in it vaporization, the water would be driven off; but the earthy and saline sediments, in consequence of not yielding to the same degree of heat, would solidify and remain in crystalline forms. That in accordance with the chemical affinities manifested by various salts, earths, and acids held in common solution, during the process of separation by vaporization, distinct deposits should be found of these salts and other substances, produced by the modifying influences above mentioned. And lastly, that as the salts, which were separated from their earthy associates in the act of crystallization, underwent distinct precipitation, alternate layers of salt and earth should be found occupying the bottoms of hollows where such operations took place.

Having come to those conclusions by reasoning *a priori*, we only now require to ascertain what is the experience of geologists founded on actual research. For, if our ideas are correct, deposits of saline ingredients associated with gypsum, commensurate to the extent of the elements employed, should be discovered in and amongst the wide-spread ranges of formations classed under the designations of the New Red Sandstone, the Oolitic, and the Cretaceous groups, and even in some of the older members of the Tertiary formations, because these are they which, according to this theory, were formed by the deposition of the debris arising from the earth's first rotation. To be convinced that the findings of geologists are perfectly accordant with this, and that these saline and gypseous deposits have hitherto baffled all endeavours to account for their existence, we shall, in the first place, recapitulate part of the *hundred and eighth* Theorem, "*That native salts, such as saltpetre, green vitriol, rock salt, sal ammoniac, borax or tincal, alum, and natron are found fossil in the earth in regular and symmetrical crystalline forms.*" And, without going into any of its evidences, in consequence of the subject matter being so rudimentary, we again refer to, and repeat the *thirty-second* Theorem, which bears more directly on the point in question, "*That the formation called the* New Red Sandstone Group

is considered to be of mechanical origin and of heterogeneous composition; containing different kinds of fossil salts associated with gypsum, and much conglomerate and breccia. That, conjointly with the oolitic group, it frequently contributes to form extended tracts of level land, having aided in filling up immense hollows on the earth's surface at a time when, or immediately after this latter had undergone a great and widely-extended revolution in its physical form, and in the condition of its vegetable and animal life. And that although most usually the deposits of rock salt are associated with the strata of the new red sandstone formation, yet they are not unfrequently found in the oolitic, cretaceous, and even in the tertiary formations."

And as this, and the evidences connected with it, were, as far as possibly consistent with our argument, intentionally deferred, when treating of the geological division of our subject, we shall now go into them somewhat in detail, recommending at the same time, a re-perusal of what has already been given;* and no set of proofs, in the whole course of this treatise, will be found more convincingly conclusive than they are in favour of the position we are endeavouring to establish, namely, *that the water was separated from the land by vaporization,* and that this could have been effected only during a period when all those concurring circumstances were simultaneously present; while this remarkable concurrence was, in turn, the immediate offspring of the *first rotation of the earth around its axis.*

We shall commence with that which is afforded us in the mineralogical illustrations of the Cuvierian theory:—

"The gypsum formation," observes Professor Jameson, "is not entirely of gypsum, but contains also beds of clay, marl, and calcareous marl. These are arranged in a determinate order when they all occur together, which, however, is not always the case. They lie over the coarse marine limestone; and the gypsum, which is the principal mass of the formation, does not occur in widely-extended plateaus, like the limestone, but in single conical, or longish masses,

* Vol. ii. chapter xxv. pp. 155—162 of this work.

which are sometimes of considerable extent, but always sharply bounded. Montmartre presents the best example of those around Paris, and there, three beds of gypsum are to be observed superimposed on each other.

"The *first* consists of alternate layers of gypsum, solid calcareous marl, and of thin slaty argillaceous marl or adhesive slate. . . . . . The *second bed* resembles the first, and only differs from it in being thicker, and containing fewer beds of marl. . . . . . The *third* or *upper bed* is by far the greatest, being in several places more than sixty feet thick. It contains few beds of marl, and in some places, as at Montmorency, it lies almost immediately under the soil. . . . . The whole of these beds, from the layer immediately over the marine limestone, to that containing the oysters, constitute the gypsum formation. Cuvier considers them as constituting two formations, viz., the gypsum and marine marl formation."*

M. de la Beche supplies us with the next evidence which we shall bring forward respecting these saliferous deposits—

"M. Elie de Beaumont observes, that in many countries the variegated marls can scarcely be separated from the lias sandstone, even artificially, as is done in the Vosges; for they appear to become one deposit, as in the environs of St. Leger-sur-Dheune, and Autun, and in the *arkose* of Burgundy. The variegated marls of the Vosges generally are, as their name implies, marked by different colours, among which the principal are wine-red, and greenish or bluish grey; they break into fragments, which have no trace of a schistose structure. In the central portion of these marls there are beds of black schistose clay, blueish grey sandstone, and greyish or yellowish magnesian limestone. The sandstone and clay contain vegetable impressions, and even coal. Masses of rock-salt occur in the lower part of the marls at Vie, Dieuze, and other parts of that district; and masses of gypsum are found in the upper and lower portions, but principally in the latter. . . . . . It is impossible to close this sketch of the supra-cretaceous rocks without noticing the important observations of Dr. Boné on those of Gallicia, wherein he establishes the fact, that the celebrated salt deposit of Wieliczka constitutes a portion of the supra-cretaceous series. Dr. Boné describes this deposit as 2,560 yards long, 1,066 yards broad, and 281 yards deep. The

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* Jameson's Illustrations of the Cuvierian Theory, pp. 411—416.

salt is termed green salt in the upper part of the mine, where it occurs in nodules with gypsum in marl. The salt sometimes contains lignite, bituminous wood, sand, and small broken shells. In the lower part the marl becomes more arenaceous, and there are even beds of sandstone in the salt. Beneath this is a grey sandstone, rather coarse, containing lignite, and impressions of plants, with veins and beds of salt. In the lower part of this stratum an indurated calcareous marl is observed, containing sulphur, salt, and gypsum. Beneath this is an aluminous and marno-argillaceous schist. From the fossils and various other circumstances, Dr. Boné concludes, that this great salt deposit forms part of a muriatiferous and supra-cretaceous clay, subordinate to sandstone (molasse). Most frequently the marly clays are merely muriatiferous; an abundance of salt, such as at Wieliczka, Bohemia, Parayd, in Transylvania, and other places, being more rare. . . . . . The red or variegated marls, which surmount the muschelkalk, possess a common mineralogical character over very considerable surfaces, such as would lead us to suppose some cause or causes exerting an influence of a similar kind over a large area. At least some of the deposit would appear chemical, more particularly the masses of gypsum and rock-salt which exist in certain situations."*

Professor Phillips, when treating on the same department of geological research, thus expresses himself—

"The irregular expanse of sea left in the region of Europe by the broken masses of land, belonging to the uplifted carboniferous rocks, was perhaps not fully filled by the next succeeding deposit of sandstones, clays, and limestone, which receives the name of red sandstone, or saliferous or poecilitic formation, but it is very extensively diffused in and beyond this area. . . . . . Salt is associated with the upper parts of this system in England, France, and Germany, where the muschelkalk is quite as saliferous as the variegated marls, to which apparently salt is confined in England.

"Upon the whole, then, this red sandstone system is a vast mass of sandy and argillaceous sediments of a peculiar aspect, accompanied more than any others yet known by salt and gypsum, generally deficient in organic remains, and only locally inclosing strata of limestone, which commonly are characterized by abundance of magnesia.

* Manual of Geology, pp. 390, 246, 409.

. . . . . Several reasons might be adduced to justify an opinion, that the time occupied in the production of the whole system was comparatively short, such as the general uniformity of its composition, the deficiency (except in limited regions) of limestones; the peculiar chemical and mineral character of these limestones; the general paucity of organic remains; the frequency of conglomerates and local admixtures of fragments of igneous rocks; all these circumstances seem to indicate the predominance of an unusual series of agencies."*

Mr. Lyell, though very succinct with respect to the saliferous formations, supplies us with the following pointed evidence:—

"The term saliferous marl and sandstone," he observes, "has been applied to the upper new red system, because it is in this group that rock-salt and salt springs occur in Cheshire and other parts of England, where the alternating beds of red and green marl, gypsum, and rock-salt sometimes exceed 600 feet in thickness. The gypsum is generally fibrous, and intercalated very irregularly between the laminated argillaceous beds. The rock salt is sometimes clear and white, but is usually reddened by the argillaceous sediment with which it is associated. At Northwich, in Cheshire, are two beds of solid rock-salt, which are, together, not less than 60 feet in thickness. The origin of these vast deposits of muriate of soda is still one of the most obscure problems in theoretical geology."†

"Hitherto," observes the illustrator of the Huttonian Theory, "we have enumerated those fossils that are either not at all, or very sparingly, soluble in water. There are, however, saline bodies among the mineral strata, such for instance as rock salt, which are readily dissolved in water; and it yet remains to examine by what cause their consolidation has been effected. . . . . . If the theorists who consider water as the sole agent in the mineralization of fossils refuse to call to their assistance any other than their favorite element, they will not find it easy to answer this question, and must feel the embarrassment of a system, subject to two difficulties, so nicely, but so unhappily adjusted, that one of them is always prepared to act whenever the other is removed. If, on the other hand, they

* Treatise on Geology, pp. 119, 123, 129.

† Elements of Geology, vol. ii. pp. 90, 91.

will admit the operation of subterraneous heat, it appears possible, that the local application of such heat may have driven the water, in vapour, from one place to another, and by such action often repeated in the same spot, may have produced those great accumulations of saline matter that are actually found in the bowels of the earth. But granting that either in the way just pointed out, or in some other that is unknown, the salt and the water have been separated, some further action of heat seems requisite, before a compact and highly indurated body, like rock salt could be produced. The mere precipitation of the salt, would, as Dr. Hutton has observed, form only an assemblage of loose crystals at the bottom of the sea, without solidity or cohesion; and to convert such a mass into a firm and solid rock, would require the application of such heat as was able to reduce it into fusion. The consolidation of rock salt, therefore, however its separation from the water is accounted for, cannot be explained but on the hypothesis of subterraneous heat. Some other phenomena that have been observed in salt mines, come in support of the same conclusion. The salt rock of Cheshire, which lies in thick beds, interposed between strata of an argillaceous or marly stone, and is itself mixed with a considerable portion of the same earth, exhibits a very great peculiarity in its structure. Though it forms a mass extremely compact, the salt is found to be arranged in round masses of five or six feet in diameter, not truly spherical, but each compressed by those that surround it, so as to have the shape of an irregular polyhedron. These are formed of concentric coats distinguishable from one another by their colour, that is probably by the greater or less quantity of earth which they contain, so that the roof of the mine, as it exhibits a horizontal section of them, is divided into polygonal figures, each with a multitude of polygons within it, having altogether no inconsiderable resemblance to a *mosaic* pavement. In the triangular spaces without the polygons, the salt is in coats parallel to the sides of the polygons. . . . . . It is clear that the whole mass of salt was fluid at once, and that the forces, whatever they were, which gave solidity to it, and produced the new arrangement of its particles, were all in action at the same time. The uniformity of the coated structure is a proof of this, and above all, the compression of the polyhedra, which is always mutual, the flat side of one being turned to the flat side of another, and never an angle to an angle, nor an angle to a side. The coats formed as it were round so many different centres of attraction, is also an appearance quite inconsistent with

the notion of deposition; both these, however, are compatible with the notion of solidity acquired by the refrigeration of a fluid, where the whole mass is acted on at the same time, and where no solvent remains to be disposed of after the induration of the rest. Another species of fossil salt, the Trona of Africa, exhibits appearances equally favourable to the theory of igneous consolidation. . . . . . It contains but about one-sixth of the water of crystallization essential to this salt when obtained in the humid way; and, what is particularly to be remarked, it does not lose this water, nor become covered with a powder, like the common alkali, by simple exposure to the air. It is evident, therefore, that this fossil does not originate from mere precipitation; and when we add, that in its sparry structure it contains evident marks of having once been fluid, we have little reason to entertain much doubt concerning the principle of its consolidation. Thus, then, the testimony given to the operation of fire, or heat, as the consolidating power of the mineral kingdom, is not confined to a few fossils, but is general over all the strata."*

To conclude the evidences respecting these vast and widely-spread deposits of *native salt*, those undeniable memorials of the transformation of a watery-bound sphere into a terraqueous globe, we shall give an abstract, and we regret that the object of our work obliges us to abridge it, of the enlivening description with which Mr. Miller has favoured us, of the salt works at Droitwich:—

"The prevailing geological system in this part of England," he observes, "is the new red sandstone, upper and lower. It stretches for many miles around the Dudley coal basin, much in the way that the shires of Stirling and Dumbarton stretch around the waters of Loch Lomond, or the moors of Sutherland or the hills of Inverness-shire encircle the waters of Loch Shin or Loch Ness. In the immediate neighbourhood of the basin we find only the formations of the lower division of the system, aud these are of comparatively little economic value. . . . . . But while the lower division of the new red is thus unimportant, its upper division is, we find, not greatly inferior in economic value to the coal measures themselves. It forms the inexhaustible storehouse of our household salt, all that we employ in our fisheries, in our meat-curing establishments for

* Illustrations of the Huttonian Theory, pp. 52—56.

the army and navy, in our agriculture, in our soda manufactories, all that fuses our glass, and fertilizes our fields, &c. . . . . . By pursuing southwards, for seven or eight miles, the road which, passing through Hales Owen, forms the principal street of the village, we rise from the lower incoherent marls, soft sandstones, and calcareous conglomerates of the system, to the equally incoherent marls, and nearly equally soft sandstones of its upper division; and some five or six miles further on, reach the town of Droitwich, long famous for its salt springs. There were salt works there in the times of the Romans, and ever *since* the times of the Romans. . . . . . Droitwich was altogether, as I saw it, a sombre looking place, with its grey old church looking down upon it from a scraggy wood-covered hill; and what struck me as peculiarly picturesque was, that from this dark centre there should be passing continually outwards, by road or canal, waggons, carts, track-boats, barges, all laden with pure white salt, that looked in the piled-up heaps like wreaths of drifted snow. There could not be two things more unlike than the great staple of the town, and the town itself. . . . . . As I saw the vats seething over the furnaces, some of them already more than half-filled with the precipitated salt, and bearing atop a stratum of yellowish-coloured fluid, the grand problem furnished by the saline deposits of this formation rose before me in all its difficulty. Geology propounds many a hard question to its students. . . . . . Here, now, are these briny springs welling out of this upper new red sandstone of central England, springs whose waters were employed in making salt two thousand years ago, and which still throw up that mineral at the rate of a thousand tons apiece weekly, without sign of diminution in either their volume or their degree of saturation. At Stoke Prior, about three miles to the east of Droitwich, a shaft of about four hundred and sixty feet has been sunk in the upper new red, and four beds of rock salt passed through, the united thickness of which amount to eighty-five feet. Nor does this comprise the entire thickness, as the lower bed, though penetrated to the depth of thirty feet, has not been perforated. In the salt mines of Cheshire, the beds are of still greater thickness. . . . . . And in Poland and Spain there occur salt deposits on a larger scale still. The saliferous district of Cordova, for instance, has its solid hills of rock salt, which nearly equal in height and bulk Arthur's Seat taken from the level of Holyrood House. How, I enquire, were these mighty deposits formed in the grand laboratory of nature? Formed they must have been, in this part of the world, in an era

long posterior to that of the coal; and in Spain, where they belong to the cretaceous group, in an era long posterior to that of the oolite. They are more immediately underlaid in England by a sandstone, constituting the base of the upper new red, which is largely charged with vegetable remains of a peculiar and well-marked character; and the equally well-marked flora of the carboniferous period lies entombed many hundred feet below. All the rock salt in the kingdom must have been formed since the more recent vegetation of the red sandstone lived and died, and was entombed amid the smooth sands of some deep sea bottom. But how formed? Several antagonistic theories have been promulgated in attempted resolution of the puzzle. By some the salt has been regarded as a volcanic product ejected from beneath; by some, as the precipitate of a deep sea overcharged with saline matter; by some, as a deposit of salt water lakes cut off from the main sea. . . . . . It seems fatal to the first theory, that the eras of plutonic disturbance in this part of the kingdom are of a date anterior to the era of the saliferous sandstone. The Clent Hills belong to the latest period of trappean eruption traceable in the midland counties; and they were unquestionably thrown up, says Murchison, shortly after the close of the carboniferous era, many ages ere the saliferous era began. Volcanoes in the neighbourhood of the sea, and there are but few very active ones that have not the sea for their neighbour, deposit, not unfrequently, a crust of salt on the rocks and lavas that surround their crater; but we never hear of their throwing down vast saliferous beds, continuous for great distances, like those of the new red sandstone of England. And further, even were salt in such huge quantity an unequivocally volcanic production, how account for its position and arrangement here? How account for the occurrence of a volcanic product, spreading away in level beds and layers, for nearly two hundred miles, in one of the least disturbed of the English formations, and forming no inconsiderable portion of its strata? As for the second theory, it seems exceedingly difficult to conceive how, in an open sea, subject, of course, like all open seas, to such equalizing influences as the ruffling of the winds and the deeper stirrings of the tides, any one tract of water should become so largely saturated as to throw down portions of its salt, when the surrounding tracts, less strongly impregnated, retained theirs. . . . . And the lagoon theory, though apparently more tenable than any of the others, seems scarce less enveloped in difficulty. The few inches, at most the few feet, of salt which line the bottoms and sides of the

lagoons of the tropics, are but poor representatives of deposits of salt like those of the upper old red of Cheshire; and geology, as has been already indicated, has its deposits huger still. Were one of the vast craters of the Moon, Tycho, or Copernicus, to be filled with sea-water to the brim, and the fires of twenty Ætnas to be lighted up under it, we could scarcely expect, as the result, a greater salt-making than that of Cordova or Cracow. A bed of salt a hundred feet in thickness would demand for its salt-pan a lagoon many hundred feet in depth, and lagoons many hundred feet in depth, in at least the present state of things, are never evaporated."*

Those evidences, which we have given at considerable length, conclusively prove, by means of the tangible monuments of what did then occur, that sudden and simultaneous VAPORIZATION must have taken place over all the continents, at a period when they were immersed in saline and acidulous water, holding, almost universally, much debris of the older rocks in mechanical suspension. Because, according to the manner in which water, when impregnated with such mineral elements, is separated from them by vaporization, occasioned by strong heat, and leaves the one class to deposit in stratiform masses, and the other to solidify into crystalline shapes, so do we find, by the geological development of the groups to which our attention has just been directed, that the results precisely coincide therewith, and, likewise, with what we anticipated. We are led, therefore, to conclude, that, as there has remained much material residium which the water *could not carry* with it, by vaporization, but which it would assuredly *have swept* into the ocean had it been *drained* from off the surface of the land (even had it been practicable within the short period referred to), that the former must have been the method resorted to, in obedience to the command, "Let the waters under the heaven be gathered together into one place, and let the dry land appear." *We shall assume, in consequence, vaporization to have been the method of separation;* while we rejoice to find ourselves so ably supported in this opinion by Prof. Playfair, who has so clearly and closely applied the investigated

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* First Impressions of England, pp. 177—185.

facts of the case in elucidating the hypothesis of his friend Dr. Hutton; which, in the instance in question, although no allusion has been made to the *source* of the fierce heat acknowledged to have been indispensable for the production of the saline deposits, as now found to exist, coincides in every other respect with the Dynamical Theory; while this latter can alone account for all the other attendant circumstances which were so manifestly present—the evidence of previous solution—the suddenness of the dessication—and the simultaneous character of the whole consolidating process.

We consider this an opportune occasion to warn our readers against their allowing any misconception to arise from the idea which we have here suggested. We are anxious to have it clearly understood, that it was not *because there had been laws governing materialism established beforehand* that they were had recourse to at this, or at any other stage of the creation. All laws affecting materialism *were impressed upon it by the Creator himself* at the time and in the manner most conducive to the progressive development of the "decreed plan of Creation," "according to the counsel of His own will," and were thereafter rendered instantaneously subservient to its further development. And, moreover, it is in consequence of their having been then so established, that we are constrained to recognise them now; and if we wish to succeed in any undertaking, to be content to employ them; and, further, that we find ourselves unavoidably subjected to their influences.

That a clear and more abiding conception of this advertency may be formed, and our readers enabled more thoroughly to comprehend what may be brought forward in virtue of it in the sequel, they must endeavour, by a vigorous act of mental abstraction, to conceive the earth to be in the condition in which it existed, while as yet it had no rotation around its axis; when shrouded in the atmosphereless deep as with a mantle; a stranger to the influences of light, it was comparatively more under the dominion of attraction, when "darkness was upon the face of the deep." This is the condition in which we shall have to consider *that it travelled for ages around the unillumined sun.* When, at length, the period arrived—foreseen by the Creator from all eternity—in which material

LIGHT became essential for the development of the same progressive plan, and its elements having been prepared, the Light was introduced; thenceforward we shall require to look upon the earth and all materialism as being subjected to the influence of a new and additional comprehensive law. The second universal *law* of matter—EXPANSION.*

The attractive and expansive principles were, from this period, placed on their present footing of determinate antagonism. The introduction of the primary LIGHT and its division from the darkness caused rotation around an axis as its immediate effect; while this, in turn, gave rise to a transitory influence, of great power during the brief period of its existence—CENTRIFUGAL IMPETUS—one of the most important of the secondary agencies employed in forming the earth, and also to another result of greater permanency, but of less ardent power—the alternation of day and night; one which, when estimating all these consequences in a meteorological point of view, we cannot, by any means, overlook.

Nor is it altogether sufficient for our present purpose to be able to estimate the *separate* effects of all those influences, or even their reciprocal effects upon each other. We must scrupulously attend to the results which emanated from the ORDER of their introduction into the material universe, and from the *precise* period when they were ordained to come into operation. These two essential circumstances denote more clearly than any other the ORIGIN of these important and comprehensive laws: perhaps more so even than their amazing power and comprehensive extent—great as both of these are—inasmuch as they more evidently point out an exercise of surpassing wisdom in the determination of the junctures when each should be brought into successive exercise.

Darkness, or attraction, was allowed first comparatively to

* We have already clearly pointed out the source from whence we consider the expansive principle of the primeval world to have emanated, before the formation of the physical light, on the first day of the Mosaic week—"The Spirit of God moved on the face of the waters." We consider it opportune, however, to remind our readers, at this juncture, of what we have adduced on the subject, and to refer them again to the divinely revealed authority of Scripture, for the only elucidation which *can* be given.—AUTHOR.

wield its influential sway, until that which was wrought out under its shadowy covering, by the immediate exercise of Divine power, should be prepared for the reception of the expansive principle—LIGHT, which awakened the perfected materials from their uterine slumber, and by its concomitant power of centrifugal impetus placed them where, all along, they had been destined eventually to be located.*

This exercise of mind will enable us not only more fully to realize the existence of an Omnipotent Power, and the exercise of an unlimited Will, but, likewise, to trace the profound wisdom of the choice of periods, when these other attributes should be made manifest by their results. And, at the same time, it will assist us to recognise the consequent modifications produced by each successive law on the combined influences of those which had preceded it; such, for example, as the effect of the alternation of evening and night, after the light of *morning* and of the day, upon the *heavens*, surcharged with watery vapour, when "the waters under the heaven" were ordained to "be gathered into one place." This alternation of the "evening and the morning," comprising a revolution of the globe, although not denoted, as now, by the concentrated light of the sun, shuts us up to believe, that there must have been a corresponding alternation with respect to the primary light during the first three days, which pro-

* Long after the foregoing was written, we encountered the following passage in Mr. Whitehurst's work, which appears so confirmatory of the advantages of quiescence to the operations we assume to have been taking place during the non-rotatory period, that we here transcribe it:—"The component parts of the chaos," says that philosopher, "having thus arrived at a state of rest, with respect to the effects arising from gravity and centrifugal force, began more immediately to act according to their affinities, or the laws of elective attraction; for, according to the second proposition, particles of a similar nature attract each other more powerfully than those of contrary affinity, or equality. But, to illustrate this, let us suppose that if a variety of salts were dissolved in one and the same menstruum, or mass of water, it will come to pass that particles of a similar nature will unite and form the same select substances as they were before solution; provided the menstruum remains perfectly quiescent. But, on the contrary, no union will take place among them, for the particles of the several salts will remain in a state of solution equally diffused throughout the whole mass of water; rest being so essentially necessary to the union of similar substances. (Whitehurst's Theory, pp. 33, 34.)

duced somewhat similar effects, because such is announced in the significant language of scripture, "the evening and the morning were the second day;" while the immediate consequences of such a change, from the comparative light of morning to the darkness of the evening, would be to promote condensation, and the sequent discharge of water from the overloaded clouds.

While, as regards the influence of the alternations of day and night, in meteorology, it is sufficiently important to be invariably referred to by writers on that interesting subject. Take the following as some of the innumerable instances which might be given:—

"During night," says Mr. Hutchinson, "the capacity of the atmosphere for moisture, in consequence of the diminution of temperature which then ensues, is considerably less than during day. These observations explain why more moisture is converted into clouds and mist, and precipitated upon the surface of the earth in the form of dew and rain during the night than during the day." Again, "The transition from the maximum temperature of day to the minimum of night produces, in a given number of hours, a greater reduction of temperature than the transition from the maximum of summer to the minimum of winter,"* and so forth.

Dr. Thomson, in his prefatory chapter, observes—

"Of the influence exerted upon meteorology by the physical conformation of our globe, and the motions thus briefly described, we would observe, that as in the sequel, reference will occasionally be made to the former, here we will confine our introductory remarks to the latter. The influence of the diurnal motion need not detain us; by it we have the agreeable transition from darkness to light, and from the cool of night to the warmth of day. We have, thus, diurnal extremes of temperature, and, through the power which caloric possesses of suspending aqueous vapour, changes in the humidity of the atmosphere; we have also mutations in the density of the aerial fluid surrounding us, and vicissitudes in its electric tension."†

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* Hutchinson's Principles of Meteorology, pp. 21, 22, 47.

† Introduction to Meteorology.

After what has been so sedulously inculcated with respect to the meteorological results of these "mutations of density," and "vicissitudes of electric tension," we need hardly remind our readers, that "the amount and tension of vapour in the atmosphere is wholly regulated by caloric;" and that "the rate of evaporation is inversely as the density of the air." Consequently, under all its aspects, the alternation of night would be productive of the condensation of aqueous vapour, and its discharge in the form of rain into the "one place"—the seas of our present world.

It will be conducive to the same preparedness of mind, to reflect on the *description* of *forces* which were then dominant over nature. They were all, as we have elsewhere observed, of a *direct* tendency. Attraction propended in straight lines from the periphery toward and through the centre. Expansion, on the contrary, from the centre towards the circumference. Centrifugal impetus, caused by rotation, partook of the character of expansion. We nowhere discover any traces of that *lateral tendency* in the motion of matter which is apparently indifferent whether the direction be to the one side or to the other; and it was precisely when such lateral motion was absolutely essential; and when by the previous formation of the atmosphere, the region of least friction, it could be most effectually employed, that it appears, from the tenor of the command, "Let the waters under the heavens *be gathered* together," that *clouds* were first made to conglomerate, and on their vapoury wings, to gather the surplus water of the heavens into those deposits which had been prepared for them; when he who could alone accomplish it by the breath of his mouth, "brake up for them his decreed place, and set bars and doors upon them, and said, hitherto shalt thou come, but no farther; and here shall thy proud waves be stayed." A conclusion which will appear more proper still, if we reflect for a moment, that without the lateral movement of surcharged clouds, there could, humanly speaking, have been no fulfilment of the command. We have seen, *by the material residium of crystalline salts and extensive deposits of mineral debris*, that the separation between the land and the water took place by means of vaporization, during which process the aqueous part would be

caused to evaporate in straight lines from the surface of the heated earth; and we now further become persuaded, that unless there had both been lateral motion, in various directions amongst the clouds, and that they had been charged with surplus watery vapour, there could have resulted *no "gathering together."* So long as the direct forces continued paramount, there might have been a dispersion like rays to or from a centre; but there could have been no result corresponding to *aggregation*, or *"gathering together."* That such is really the case, a moment's reflection will, we think, convince every one. We can imagine, that the watery vapour might, by the centrifugal impetus, or by expansion, have been impelled high into the atmosphere from the surface of the earth in parallel lines; and have been drawn down again towards the centre by that of attraction, or we may conceive it to have vaporized by the direct action of heat. But any motion corresponding to aggregation or free lateral movement, we cannot possibly conceive to have arisen out of either the one or the other of those forces producing motion, nor even from any of their possible combinations; while the probable consequences of the application of *direct* forces to the case in question, namely, *the separation of the water from the land without removing the material residium*, could not have been effected, nor even assisted in the slightest degree, by the consequent operation which would have ensued by the mere raising of the water and letting it descend again *on the same surface*. Nothing, so far as we can conceive on the subject, but the formation of clouds, and their easy and rapid movement, by means of the atmosphere, could have wrought out the design for which the command was given, " Let the waters under the heaven be gathered together into one place, and let the dry land appear." Without motion there could have been no " gathering together," and having shown that neither of the direct motions then known, nor any combination of them could have produced this effect, we are led irresistibly to the only conclusion which remains, namely, *that a motion of aggregation was by this new command introduced into the material universe*, and that this was effected by means of electricity or light.

This conclusion, involving very important consequences, as

far as the new formed atmosphere is concerned, will lead us, by a little patient investigation, to the discovery of another very striking exemplification alike of the infinite wisdom of the Creator, and of the truthfulness of the revelation which he has been pleased to put on record of those works which he performed, when there was no mortal eye to behold his operations.

That we are fully borne out, in this unreserved assumption, by the dicta of meteorologists, we take occasion to show by the following opinions which they have expressed on the subject, quite irrespective of our cosmographical conceptions:—

"It is evident," says Mr. Hutchinson, "upon reviewing the subject"—the formation of clouds—"that, with the exception of some of the circumstances enumerated under the first cause of the existence of clouds, WIND is a necessary agent in their formation. If there were no such thing as wind, which would be the case if the air was not liable to expansion by means of heat, no clouds, with the exception of mists and fogs, could ever make their appearance. All the moisture evaporated in such circumstances during day, would be returned to the earth in the form of dews, or falling mists, during night. In general, then, it may be remarked, that whatever effect a wind of moderate velocity is calculated to produce upon the hygrometric condition of the atmosphere, will be increased by every increment in its velocity, and diminished by every decrement."

Again—

"The circumstance of clouds gathering together in heaps, so as to form the several descriptions of cloud, proves that, though the vesicles of which they are composed be mutually repellent within a certain distance, they are mutually attractive beyond that distance. If the vesicles were mutually repellent at all distances, instead of congregating together into those masses which we call clouds, they would separate as far as possible from each other, and diffuse themselves equally throughout the atmosphere."*

"The proximate cause of the formation of clouds," says Dr. Thomson, "is the loss of caloric in the humid atmosphere, and

* Principles of Meteorology, pp. 102, 103, 167.

condensation of the moisture ; but we are still ignorant of the ultimate cause of the phenomenon."

And after alluding to several explanations which have been attempted, he continues—

"A far more plausible theory than the first attributes it to currents, upwards and horizontal (Gay Lussac). Another hypothesis (Luke Howard), assigns it entirely to electrical agency. We know that electricity has much to do with the phenomenon; it is largely developed during evaporation, as was long ago shown by Volta, Saussure, Lavoisier, Laplace, and Bennet, while the vapour acquires that kind denominated *positive*, the water which remains being *negatively* charged. . . . . . Why certain clouds should be positively and others negatively charged, is not yet determined, though the fact is incontestible. Mr. Luke Howard has proved that the electricity of the nimbus cloud is positive internally, and negative at the circumference ;"* and so forth.

But, before proceeding farther to the scientific illustration and confirmation of that to which we now allude, we beg to make one or two observations respecting what we consider to be the spirit in which this remarkable portion of Scripture is to be received and understood. The expression "Let" when used in the manner in which, for example, "God said, *Let* there be Light," seems to us, to imply *an encroachment, to the extent to which that command went, on laws of materialism previously imposed by the Creator himself.* "Let there be light" overcame to a certain degree the prior dominion of attraction, and when, in continuation, it was "divided from the darkness," the light overcame it by the centrifugal impetus it engendered, which is testified by the elevation of the continental ridges, &c, "Let there be a firmament," again overcame attraction, as is proved by the expansion of the atmospheric elements affected by their combination with light. At the same time it is necessary to notice a speciality in the expressions of this latter command; for, it is immediately subjoined, "AND GOD MADE *the firmament*," signifying not only its destined stability and the utter hopelessness of any attempt to alter or to change it;

* Introduction to Meteorology, pp. 123, 124.

but likewise, that it *was an act which was never to be repeated.**

When, however, it pleased him in his infinite wisdom to issue the command which constituted that part of creation now more immediately under examination, "Let the waters under the heaven be gathered together into one place," there is no similar repetition; such as, "And God gathered together the waters," but merely the simple statement, "*And it was so.*" A distinction which, in our opinion, implies this mighty difference, that so far from this not being destined to be repeated, as in the case just cited of the firmament, it was designed purposely to be so, and was worded accordingly, in order that laws then instituted might re-operate whenever in disposition so to do; and by the formation of clouds and the gathering of their surplus water into the ocean, the earth should continue to be supplied with the moisture requisite for it.

To be assured that this is precisely what takes place by the machinery of the weather, we have only to peruse the following brief passage:—

"The parent source from whence the atmosphere, when undersaturated, derives a supply of aqueous vapour, is the ocean; and the process by which it is supplied is called evaporation. It is true that from every moist land surface evaporation also takes place. But as the land itself derives its moisture from the atmosphere, in the form of rain, dew, &c., a considerable proportion of the moisture which is precipitated upon the land would soon become thoroughly and permanently dried up, were it not supplied with humidity from the ocean, through the agency of evaporation and atmospheric currents."†

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* The incompetency to *un*make what God declares *He* made has been most signally manifested. In the words of the *fifty-fifth* Theorem it is asserted, "*That oxygen, nitrogen, and hydrogen gases have been severally submitted, by the first chemists of the age, to the enormous pressure of eight hundred atmospheres, without their having succeeded in reducing either of them to the liquid state; although many other gases have been liquidized by their vigorous and well-directed exertions.*" And again, in the *eighty-fifth* it is stated, "*That the nitrogen and oxygen gases of the atmosphere have never either been liquidized, or rendered incandescent.*" The authorities on whose dicta these assertions are made, can, if desired, be consulted for fuller details.—AUTHOR.

† Principles of Meteorology, by Hutchinson, pp. 17, 18.

We have so frequently noticed the important fact, the tendency of the forces, which existed previously to the giving of the command above referred to, to produce *direct* motion, that we must apologise for alluding to it again; but it is most essential to bear in mind, that one of the immediate consequences of this tendency, that is, of direct forces, would be to saturate the atmosphere with equal proportions of watery vapour for all given zones of latitude; or, in other words, the action and reaction of the direct forces on matter would be equalized all over the earth's surface, in accordance with the static condition of equilibrium of a sphere in rotation; that is, all portions of the atmosphere would become equally charged with watery vapour in proportion to what they could respectively receive. There would, indeed there could have been no unequal loading of any part of it with aqueous exhalations, for there existed no force which could propel matter out of direct lines, or of olique lines *parallel* to each other; this advertency is quite irrespective of the immediately subsequent action of the heated and elevated continental ridges. We merely allude to the general fact of the tendency of direct forces at present, but we shall have occasion to recur to and make use of it hereafter. Meanwhile we must endeavour to learn, from the testimony of scientific writers, whose announcements support the *ninety-fourth* Theorem, some of those more recondite but well established and comprehensive principles, whose combinations of action and reaction on each other, seem to govern and to give effect, by currents of wind, to the various meteorological vicissitudes, namely, "*The existence of a constituent temperature for the maintenance of water in a state of vapour. The opposite tendencies of* AIR *from the colder to the warmer parts; and of* VAPOUR *from the warmer to the colder parts of the atmosphere and terraqueous surface. The different rates at which the temperature and tension of air and of vapour decrease as they ascend from the surface of the land or sea. The different capacities for heat of these two component parts of the earth's surface. And, lastly, the unequal distribution of the electric fluid in the nephalic masses of the atmosphere, and its tendency to a state of equilibrium, seem to be the most obvious principles, whose combination and mutual action on*

each other govern and modify the meteorological state of the atmosphere."

The following evidences, on which this theorem is constructed, being very essential, we beg to direct attention to them :—

"We can suppose the earth," observes Professor Whewell, "with no atmosphere except the vapour which arises from its watery parts; and if we suppose also the equatorial parts of the globe to be hot, and the polar regions cold, we may easily see what would be the consequence. The waters at the equator, and near the equator, would produce steam of greater elasticity, rarety, and temperature than that which occupies the regions further polewards ; and such steam, as it came in contact with the colder vapour of the higher latitudes, would be precipitated into the form of water. Hence there would be a perpetual current of steam from the equatorial parts towards each pole, which would be condensed, would fall to the surface, and flow back to the equator in the form of fluid. We should have a circulation which might be regarded as a species of regulated distillation. . . . . .

"If we had the earth quite dry, and covered with an atmosphere of dry air, we can trace in a great measure what would be the results, supposing still the equatorial zone to be hot, and the temperature of the surface to decrease perpetually as we advance into higher latitudes. The air at the equator would be rarefied by the heat, and would be perpetually displaced below by the denser portions which belonged to colder latitudes. We should have a current of air from the equator to the poles in the higher regions of the atmosphere, and at the surface a returning current setting towards the equator to fill up the void so created. . . . . The effect of a heated surface of land would be the same as that of the heated zone of the equator, and would attract to it a sea breeze during the day time, a phenomenon, we also know, of perpetual occurrence.

"Thus in the lower part of the atmosphere, there are tendencies to a current of air in one direction, and a current of vapour in the opposite; and these tendencies exist in the average weather of places situated at a moderate distance from the equator. The air tends from the colder to the warmer parts, the vapour from the warmer to the colder.

"The various distribution of land and sea, and many other causes, make these currents far from simple. But, in general, the air cur-

rent predominates, and keeps the skies clear, and the moisture dissolved. Occasional and irregular occurrences disturb this predominance; the moisture is then precipitated, the skies are clouded, and the clouds may descend in copious rains.

"These alternations of fair weather and showers appear to be much more favourable to vegetable and animal life than any uniform course of weather could have been. *To produce this variety, we have two antagonist forces, by the struggle of which such changes occur. Steam and air, two transparent and elastic fluids, expansible by heat, are in many respects and properties very like each other; yet, the same heat similarly applied to the globe, produces at the surface currents of these fluids tending in opposite directions.* And these currents mix and balance, conspire and interfere, so that our trees and fields have alternately water and sunshine; our fruits and grain are successively developed and matured. Why should such laws of heat and elastic fluids so obtain, and be so combined? Is it not in order that they may be fit for such offices? There is here an arrangement which no chance could have produced. The details of this apparatus may be beyond our power of tracing; its springs may be out of our sight. Such circumstances do not make it the less a curious and bountiful contrivance; they need not prevent our recognising the skill and benevolence which we can discover."*

"Variations of temperature on different parts of the earth's surface," says Mr. Hutchinson, "disturb the atmospheric equilibrium, and give rise to aerial currents; while, on the other hand, aerial currents, according as their direction is from a cold or a warm climate, produce important alterations in the temperature of the incumbent atmosphere. Again, variations in the atmospheric temperature are principally instrumental in the formation and dissolution of clouds; while the existence of these reduces the temperature of the subjacent atmosphere during day and summer; and augments during night and winter, and unitedly produce the varied machinery of the weather. . . . . .

"Winds, in every case, whether at the level of the sea, or at any elevation above it, originate in simultaneous inequalities of atmospheric density, or simultaneous inequalities of incumbent atmospheric pressure at corresponding levels, in different places. And, according to the principle of fluids in their motions, obeying the prepon-

* Bridgewater Treatise, pp. 96—101.

derance of pressure, the direction of the wind must always be from where the incumbent pressure is greater, to where it is less . . . .

"Whatever, therefore, produces a simultaneous difference of temperature in different portions of the atmosphere, at equal altitudes above the level of the sea, necessarily give rise to qualities of barometrical pressure, and thus remotely become the cause of wind.

"Agreeably to the preceding observations, the most general cause of wind is the gradual diminution of the mean annual temperature from the equator towards the poles; and the prevailing direction in which the upper part of the atmosphere moves is from the warm towards the colder climates, viz., from the equatorial towards the polar regions. And, on the contrary, the prevailing direction in which the lower half of the atmosphere moves, is from the cold to the warmer climate; and accordingly from the polar towards the equatorial regions."*

The recent work of Dr. Thomson affords us the following corroboration:—

"When by any cause the atmospheric molecules are disturbed, the motion communicated to the air is denominated wind: it arises as a consequence of changes in the density of the atmosphere. Like water seeking its own level, the particles of air rush to supply the partial void, with a velocity and impetuosity proportioned to the existing cause; so in the higher regions, those particles which, expanded by heat, have ascended by reason of their diminished gravity, flow out according to a similar law, and thus two currents are established, one on the surface of the earth, and the other considerably above, moving in opposite directions."†

"It will be recollected," observes Mr. Reid, "that there are two great powers acting upon every kind of matter, *attraction* and *repulsion*. This latter principle is generally believed to be the same as *heat*. If *cohesion* were the sole ruling power, the world would be a dull, inert mass, for the tendency of cohesion is to draw the particles of bodies into close contact with each other, and to preserve them in that state. But the repulsive principle, by driving asunder the particles of bodies, infuses life and activity into inanimate objects.

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* Hutchinson's Principles of Meteorology, Introduction, pp. 269, 131, 272.
† Introduction to Meteorology, p. 377.

"To illustrate this, it will be sufficient to mention, that without the power of heat or repulsion, there could be no winds, rain, dew, rivers, streams, or springs."*

With these expositions, on this abstruse subject, the complex and seemingly capricious machinery of the weather, we shall conclude this chapter, that we may enjoy a slight respite, and have time to meditate on what we have perused before proceeding to its application in conformation of the Dynamical Theory; and ere we attempt to show by what means these meteorological phenomena, and the formation of the atmosphere, or "firmament," at this juncture, can be made available, to convince our readers, *that there was a long but indefinite period, during which the earth had no rotation around its axis.*

* Popular Treatise on Chemistry, p. 22.

SECTION VIII.

COMPLETION OF THE ATMOSPHERE; SEPARATION OF THE SEA FROM THE LAND; AND THEIR IMMEDIATE COMBINED RESULTS.

CHAPTER XXXIV.

Preliminary observations. Different consequences which result from the application of the Expansive principle to the Aerial and to the Aqueous bodies of the atmosphere exemplified by what took place at the epoch alluded to. Evidence that it was at this juncture the Atmosphere was completed, and the Sea and the Land were separated from each other. Concurring testimony that these events were effected by VAPORIZATION. Scientific evidences as to the action and reaction of these great natural bodies on each other, and their beneficent results. A corroborative line of proof adopted and made good by the character and capabilities of the Phanogamous division of plants; and the opportune period recorded in Scripture as that of their formation.

THE immediate results of the first rotation of the earth around its axis would be to elevate continental ridges, intensely heated; to depress oceanic hollows of corresponding magnitude; to carry upwards, by means of the former, immense longitudinal waves, the latter retreating and carrying down, to a certain extent, masses of water, corresponding to the spaces upon which they rested; while the upper strata of water would be dispersed in great tenuity, by the general rotatory impulse, augmented in the zones above the continents by the incandescent mountain chains thrust into their midst. Before this period, it must be reiterated, there existed no motion of matter, except in straight lines, either to or from the centre, or diagonal thereto as a compound of those primary directions, but none which could cause particles of inert matter to move out of parallelism; while there now exists, as we have seen by the theorem and evidences last appealed to

in the previous chapter, a law in nature, whereby the aerial portion of the atmosphere propends from the colder to the hotter regions; and the vaporous constituents from the hotter to the colder places, without reference to direction beyond what is impressed upon them by these irresistible impulses. And another constitutional law, by which its aqueous associate is induced to form itself into vaporous vesicles, of wonderful tenuity, possessing diffusive principles within and immediately around themselves, yet with general attractive affinities by which they congregate or gather together into those gorgeous but fantastic forms which visible vapour or clouds assume; and having been made aware of these several conditions, and of the existing phenomena connected with the comprehensive machinery of the weather, the mind may now be considered capable of making the requisite application of them to the subject more immediately under consideration.

Alluding again to that normal law of materialism, to which we have so frequently had occasion to refer—"that inert matter can neither generate, alter, nor overcome motion in itself"—and being without the knowledge of the existence, up to the period to which we allude, of any source of motion save in direct lines, while we are firmly persuaded of the insufficiency and inappropriateness of this description of motion, to effect the separation of the water *from the earthy and the saline residium, which exists to this day as an incontestible proof of the separation which actually took place;* we are reduced to one of those unavoidable dilemmas into which reliance alone on the laws of materialism would infallibly lead us. *Motion*, impelling matter in *parallel* lines could never have effected what we are constrained to admit has been done. And it is precisely when thus critically circumstanced, when we cannot take one step forward of ourselves, that the revelation of the interference of the Creator at this opportune juncture relieves us from the difficulty: "Let the waters under the heaven," (not under the *firmament*, be it observed), "*be gathered together*," (there could be no gathering together in *parallel* lines), "and let the dry *land* appear."

Now, from what has been said, it will not be difficult to imagine the land to have been entirely enveloped by watery

vapour, which, by reason of the causes then in combined operation, especially of the diffusion principle, had risen up, and, for a limited period, was sustained by the new-formed atmosphere, in which, as there had yet been no lateral motion, the mass of encircling vapour remained unbroken and undispelled; and that, had there existed a mortal eye within the compass of the universe, that eye, however space-penetrating, however keen, could not have distinguished the continental ridges: to it the land would not, as yet, have appeared.

It may be well at this juncture to remember, that the principal agent, or impelling power, which, we are told, the Deity chose to wield while He was thus putting forth those manifestations of creative energy, was the *expansive principle of light in its primary condition;* moreover that the direction in which it impinged upon the world, while in the character to which we are now referring, was tangential; and, from the causes so frequently alluded to, that the surface of the earth was divided into several immense longitudinal ridges of high temperature, being our present continents; and of corresponding colder depressed regions, those which constitute the oceans of our day.

And, bearing these few important circumstances stedfastly in mind, we have only to recur to what we have just made so clearly to appear from the announcements of philosophy, when declaratory of the meteorological phenomena:—"*That the application of the same heat, looked upon as a synonyme of the principle of light or electricity, applied to the globe, and acting upon the two principal constituents of the atmosphere—Aqueous Vapour and Air—would produce currents of these fluids tending in opposite directions: the air tending from the colder to the warmer parts; the vapour from the warmer to the colder.*"* While the application of this double and contrary result of the same propelling power, as shown by the preceding quotation from the works of Professor Whewell and other meteorologists, is so apposite, that we have only to recur to it, to understand thoroughly and for ever, how the impartation of the primary light, and of the intense heats from the

* Theorem 94 and evidences.

continental ridges, at the period referred to, was the most fitting agency, in the hands of the Creator, to have occasioned an almost instantaneous dispersion of the watery vapour from off the warmer regions, over the continents, by transference to the colder zones above the oceanic depressions, where, losing the latent heat which retained the aqueous portion in a vaporous state, it would be discharged in copious rain, and thereby fulfil the command—" Let the waters under (the temperature of) the Heaven, be gathered together into one place, and let the dry *land* appear." There is so much sublimity in the simplicity of this announcement: so much of omnipotence combined with omniscience; a handling of the vast materials of the universe with so much ease; and the constraining of potent and comprehensive powers to fulfil a definite purpose, that it is, we apprehend, scarcely possible to peruse this portion of scripture, and view it as we have now done, without confessing, that it is the announcement of the Spirit of HIM who alone could so deal with those elements, and cause them to produce those monuments of His power which appear everywhere in creation. This will also enable us to understand, that it is solely as the permanent consequences of the command then given, *that watery vapour still propends from the hotter to the colder regions, in opposition to its atmospheric associate*, the *aerial* part; that they are, in fact, differently acted upon by electricity, and not from any inherent principle which resided in these before that announcement went forth from the Creator.

The reasons so strongly urged by us in favour of the position assumed, namely—*That the waters were separated from the land by vaporization*, are all borne out and confirmed by what we have just stated. There existed powerful and influential motives for vaporization having rapidly, extensively, and effectually taken place all over those parts of the earth's surface which now constitute its terraine portion. It was absolutely essential, for the completion and adaptation of those portions for the world's future occupants, that the various mineral salts, soils, and sand should not be swept away, when the water with which they were combined was separated from the dry land, but that the aqueous portion should be insensibly and almost invisibly wafted away, like a spirit, from the salts

and soils; and that they should assume their dry and crystalline state, to remain as blessings to entire races of beings destined to employ them, long thereafter, for their respective purposes. And thus the sub-aqueous heat, arising from the fused mountain chains, was simultaneously applied beneath to occasion rapid evaporation; whilst the expansive principle of light was caused to impinge tangentially upon these vaporous exhalations, in a direction external to the surface, and thereby to complete their entire separation. In short, no conceivable combination of circumstances could have been more complete or more favourable for the accomplishment of the object then designed, as far as regards the terraine part of the world's surface.

No such end being desired with respect to the depressed portions of the earth's surface, destined to receive the waters of the ocean, the same over-ruling wisdom, which applied heat to the elevations, arranged that these should be less capable of producing evaporation; and by this opposite tendency they were caused to forward the work of creation almost as directly as the evaporizing process over the land. We do not mean by this to assert, that there was absolutely *no* friction, and consequently *no* heat occasioned by the depression of the oceanic hollows of the world. We believe these effects resulted from *depression* as well as from *elevation;* but owing to the description of force employed, centrifugal impetus, we are disposed to consider, that the *elevatory* movement beyond the original contour of the non-rotatory sphere, far exceeded the *depression within* that original outline; while, at the same time, the oceanic cavities would be covered by comparatively a much greater depth of water than the uprising continents, and be subjected to the application of altogether different degrees of heat and other evaporizing influences. Indeed, we cannot suppose it consistent with the wisdom and the power of God to have occasioned the vaporization of one drop of moisture unnecessarily, when we are so plainly informed, that it was His design "to gather together the waters *under* the Heaven" into "one place," and that place, as we are afterwards informed, was the "sea."

On contemplating, for a moment, the conclusion we have

just come to, it must appear to be immediately dependant upon the *first rotation of the earth around its axis;* the centrifugal impetus, engendered by this event, constituting, as a secondary cause, so essential an element amongst those employed by the Creator in the formation of those portions of His work which we have been considering, that it is altogether impossible to imagine their existence—as it has pleased the Author of Nature to form them—independently of that special force. The deduction from this, as to the *period when* the waters were separated from the dry land, is so obvious, as scarcely to require any further notice. It could only have been at the particular juncture, when the earth was first put into rotatory motion, that the centrifugal impetus necessary, as the element and the description of power which was required, could have been produced; and it is precisely at that particular period when, as scripture informs us, " the waters were separated from the dry *land*."

If we had only this announcement to strengthen our confidence, and to assure our faith in what is thus revealed, it would, of itself, be sufficient for that purpose. But when, in conjunction with this striking coincidence, we make the attendant circumstances of the creation to pass in brief review, we become strongly impressed with a conviction of the perfect adaptation of the means to the end designed; as well as of the power and wisdom which were displayed by the Creator in constraining the successive parts of his work to contribute towards the completion of that which was to follow. This feature, so characteristic of the wisest forethought, we have had occasion more than once already to point out during our exposition; but in no stage of the creation does it manifest itself more conspicuously than at the period to which we are now referring.

The increased pressure, occasioned by the completion of the atmosphere, would directly contribute to the condensation of aqueous vapour; while the downward tendency of the surcharged clouds, from the higher and more heated regions, above the continental land, towards the lower and colder spaces occupied by the oceans, the natural direction of all bodies under the influence of gravitation, and more especially

of the nephalic masses, when the equanimity of barometrical pressure is interfered with, would accelerate their descent, and render condensation and their discharge into the general reservoir of the sea more speedy and copious; a consummation which would, to a considerable degree, be likewise facilitated in succession all around the globe as the comparative warmth of the scriptural "morning" gave place to the darker and colder vicissitudes of "evening."

The following extracts, explanatory of the *land* and *sea* breezes, so common in tropical regions, bear so directly on this part of our subject, that we make no apology for inserting them:—

"The phenomena are as follow," says Mr. Whitehurst, in his Theory of the Earth:—"In the middle or hottest part of the *Day*, the sea breeze blows towards the land, in every possible direction; and in the middle or coldest part of the *Night*, the land breeze blows towards the sea, in every possible direction. Thus they alternately succeed each other, as constantly as night and day.

"These singular phenomena seem to arise from the following unalterable laws of nature, namely: those properties of the air whereby it becomes subject to rarefaction by heat and condensation by cold; and in part to the situation of the islands within the torrid zone, where days and nights are nearly equal all times of the year.

"To the above we may add the following qualities of matter, viz. That water is a conductor of heat or cold; and that the earth is a much inferior conducting substance. Hence heat and cold do not accumulate on the surface of water, but in a short time its whole mass becomes equally hot or equally cold; and the earth being a non-conducting substance, heat or cold accumulates upon its surface, and does not become diffused to any considerable depth.

"Hence it comes to pass, that the surface of land under the torrid zone, acquires much more heat than the surface of the sea: consequently the atmosphere of the former becomes more rarefied than that of the latter, and rendered thereby specifically lighter than the air at sea. The equilibrium of pressure being thus destroyed, the air upon the island ascends by the superior weight of the air at sea, which moves in all directions towards the central parts of the island, and with more or less velocity according to the different densities of the two mediums, and thus produces a sea breeze. When night approaches, the sun's heat abates, until the atmosphere at land be-

comes equally dense with that at sea. The equilibrium of pressure being thus restored, the sea breeze totally ceases and remains quiescent; till cold, increasing by the absence of the sun, accumulates on the surface of the islands, and condenses their incumbent atmospheres more than that at sea; for water being a conductor, cold becomes equally diffused throughout its whole mass, and therefore cannot accumulate on its surface. The land atmosphere being thus rendered specifically heavier than the air at sea, begins to descend by its superior weight, and then blows in all directions towards the sea; till the sun returns, and restores the two atmospheres to an equal density; the air then becomes stagnant, and remains in a quiescent state, till it is again rarefied by the accumulation of heat, as before."*

"In all maritime or insular situations in warm climates," observes another writer, "where the sun is nearly vertical, and where, accordingly, it exerts a strong heating influence, the surface of the land becomes warmer during day, and by more rapid radiation, colder during night, than that of the ocean. The result is, that the atmosphere over the land, from participating in its excess of warmth during the day, is expanded upwards, and gives rise to a current in the upper portions of the atmosphere from the land towards the sea; and this, in its turn, in accordance with the principles already explained, gives rise to a current at the surface of the earth, from the sea towards the land. . . . . . Sea and land breezes, as above explained, afford the best practical illustration of the causes which produce winds when their direction is regular, and of the principles which regulate their direction and velocity."†

Dr. Thomson confirms this when he says:—

"The *sea and land breezes* are diurnal winds, arising from causes which we have already explained. They are best studied in tropical climes, for there the exciting cause acts with greatest power. They are altogether due to solar influence; the land being heated by day more than the sea, the air above the former is more highly rarefied than that over the latter, hence a current from the sea, or a sea-breeze is established; at night the reverse is the case, for by terrestrial

* Whitehurst's Theory of the Earth, 1786, pp. 148—150, a work seldomer referred to than perhaps it ought to be.

† Hutchinson's Principles of Meteorology, p. 287.

radiation the ground becomes colder than water, and a land-wind blows to preserve the equilibrium of the atmospheric forces."*

Besides the more immediate effect, "the gathering together of the waters, and their separation from the *land*," towards which all those contemporaneous secondary causes were made to conspire, there were other events being brought about during their mutual action on each other, which were, likewise, as essential to the well-being of those races, endowed with voluntary motion, which were so soon to become the occupants of the gorgeous pedestal then preparing for their reception; and it may be well to bear in mind, that up to this period, and for a day and night thereafter, there was not a creature possessing the faculty of full and free locomotion within the precincts of the world: we might safely add, within the limits of the solar system. Whenever, therefore, we think of, or have to reason concerning motion, up to this time, we must confine our ideas to those descriptions which proceed from attraction, repulsion, or from dynamical causes.

The more recent discoveries of science, at every moment and in every branch of research, present us with continual proofs of the manifold wisdom which pervaded the operations of the Creator—the arch-chemist of nature—in his "workings of old." In that which the assiduity of chemists has lately enabled them to make out, with respect to the composition of earths, we have a striking example, alike of the wise forethought and of the prudential care which characterise the production, as recorded in Scripture, of the original earthy and mineral substances of the world, and also of the fitness of the juncture, in consideration of the abundance of the elementary constituents, when it pleased the Creator to form the earthy materials in question. But let chemistry itself bear testimony to the correctness of these observations.

Professor Donovan says:—

"Rocks, stones, and earths appear dissimilar to each other, yet observation shows, that the nature of all of them is the same. Stones and rocks are often found mouldering into earth, and earth is known

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* Introduction to Meteorology, p. 385.

to harden into stone. The process of mouldering produces no change further than breaking down the cohesion of the rock; accordingly, we find the soil at the foot of rocky mountains to contain the same ingredients as the rocks themselves. . . . . . Now, as these rocks, when broken down into small particles or powder, constitute earth, chemists have denominated the ingredients of which rocks and stones are composed, *earths;* and these are, consequently, of different kinds."

After describing minutely the composition of the precious stones, and explaining the nature of their chief components, *alumina, silica, glucina, zirconia,* and *yttria,* he goes on to state:—

"After introducing the student to the knowledge of the preceding earths, the gems have been adduced as examples, on account of their containing them in great purity. . . . . . We shall take leave of these and proceed to consider the nature of a much less costly class of minerals, although, in point of utility, some of them are of far greater importance. . . . . .

"Marbles, for instance, which are of all varieties and mixtures of colour, notwithstanding their value, are the same substance with common limestone and chalk, with a slight difference only in purity. Limestone is one of the most abundant minerals in nature; it sometimes constitutes the substance of whole mountains. . . . . . When water is poured on burned limestone it is immediately absorbed, and the lime appears as dry as ever. In a short time, however, it swells, bursts, grows hot, discharges steam, and falls to powder. The same phenomena are exhibited by marble and chalk, after burning, if similarly treated.

"There are two minerals very different from limestone or marble, and from each other, which, however, agree with limestone in the property of affording *earths,* that when water is poured on them suddenly become hot, and undergo the process of slaking. These minerals are named *carbonate of baryta,* and *carbonate of strontia,* and the *earths* obtained from them are called *baryta* and *strontia.*"*

* It should be observed, that during the period when we assume that the earths and soils were composed, the new formed atmosphere was in a peculiar condition; and it will be for us to consider how far these several carbonates of lime, of baryta, and strontia would be modified in their results by being fused and slaked in that state.—AUTHOR.

"The preceding earths are all which the ingenuity of chemists has been able to discover; and of these are composed all the gems, stones, rocks, mountains, and soils that are found throughout, and constituting the globe. From this examination we learn, that the solid parts of the globe, as far, at least, as human industry has discovered, are composed of a few earths and metals, each being presented under an astonishing variety of forms. And it will presently be shown, that the distinction between earths and metals, evident as it may appear, is not well founded, ... for of late years it has actually been demonstrated that earths are, themselves, metallic oxides. This has been shown by abstracting oxygen from them; and determining that, in each case, globules of a peculiar metal made their appearance. To metallize the earths, it is only necessary to subvert the affinity subsisting between the metallic basis and the oxygen, by means of some body having either a naturally stronger affinity for oxygen than the basis, or made to have it by art. The oxygen being withdrawn from the compound, the basis will make its appearance in the metallic state. What these means are it is not necessary here to detail; it is sufficient to say, that it was chiefly through the application of the powerful agent called *galvanism* that the difficulty was overcome; but the medium of natural affinities was sometimes sufficient. When any of these earthy metals were presented, at an elevated temperature, to the action of oxygen, the latter was absorbed, and the original earth was reproduced. The metals obtained from the earths are named aluminum, glucinum, yttrium, barium, calcium, strontium, magnesium, to which list a new metal, thorium, has lately been added.

"It appears, therefore, from the investigations of modern chemists, that the globe of the earth is one vast mass of metals of different kinds, disguised by various substances, but chiefly by oxygen."*

These extracts demonstrate, in a concise but perspicuous manner, the intimate connexion which subsists between earths, metallic oxides, and metals; while they trace them all alike back to "the great globe itself," and to the slow, progressive, but powerful agency of galvanic currents. By this we obtain, not only a clear glimpse of the way in which these mineral

* Chemistry, in Cab. Cyc. pp. 115—120.

substances were formed at first, in the womb of nature; but, likewise, of the reasons which led to the thrusting up of heated continental ridges and mountain chains, composed of these metallic substances, into the midst of a world of waters plentifully saturated with saline and oxygenous elements: whereby the prompt and abundant formation of loose earths and soils, suited for the forthcoming vegetable kingdom, took place, at the precise juncture when they were required; when they could no longer have been dispensed with, and while their earlier formation (had such been possible in the then condition of the creation) would have deprived them of much of that efficacy, which, as new formed earth and soils they essentially possessed.

Nor have we, by any means, yet exhausted the resources of science for accomplishing the pleasing duty of making manifest the manifold wisdom and providence of the Creator, especially that peculiar feature of these attributes, whereby we are taught, that from one and the same general combination of elements are made to spring several concomitant effects.

This is more than usually evident on the present occasion; for we shall be made aware, by evidences deduced from scientific sources, distinct from those which we have been quoting from, that by employing *water*, after the *atmosphere* had been formed over it, as the medium wherein the chemical combinations were conducted which produced the loose earths and soils, and by applying the heated masses underneath the water, the *refrigeration* was greatly accelerated of the heated continents and their mountain ranges; and that while the caloric which they radiated in such profusion was acting, as meant to do, with so much effect on the elements of water and air, and the associated ingredients of the former, these were reacting, as refrigerators, with as much greater an influence than would have been produced by the etherial medium or by vacuo, as their densities exceed that of these media respectively, and also by radiation into the atmosphere.

"Heat," observes Mrs. Somerville, "applied to the surface of a fluid, is propagated *downwards* very slowly, the warmer, and consequently the lighter strata always remaining at the top. . . . . . When heat is applied *below* a liquid, the particles continually

rise as they become specifically lighter, in consequence of the caloric, and diffuse it through the mass, their place being perpetually supplied by those which are more dense. The power of conducting heat varies materially in different liquids. Mercury conducts twice as fast as an equal bulk of water. A hot body diffuses its caloric in the air by a double process; the air in contact with it, being heated, and becoming lighter, ascends and scatters its caloric; while, at the same time, another portion is discharged in straight lines by the radiating powers of the surface. . . . . . Hence a substance cools more rapidly in air than in vacuo, because in the latter case the process is carried on by radiation alone. It is probable that the earth, having originally been of very high temperature, has become cooler by radiation only. The etherial medium must be too rare to carry off much caloric."*

"The constituent particles of solid bodies," we are informed by the article on Heat in the Cabinet Cyclopedia, "being incapable of changing their mutual position and arrangement, the heat can only pass through them from particle to particle by a slow process; but when the particles forming any stratum of a liquid are heated, their mass expanding becomes lighter, bulk for bulk, than the stratum immediately above it, ascends, and allowing the superior strata to descend, ... a constant series of currents upwards and downwards is thus established, and the heat is diffused by the motion of the particles among each other. . . . . .

"If, however, heat be applied to the highest stratum of the liquid, this effect cannot ensue. In fact, the heat is, in this case, *conducted through* the liquid. Liquids are, in this manner, observed to have extremely low conducting powers: for a long period they were supposed to be altogether incapable of conducting heat. . . . . .

"The process of cooling which a hot body undergoes when suspended in air, is chiefly owing to the radiation of heat from its surface; but another cause of the diminution of heat conspires with this. The particles of air in contact with the surface of the body receive heat from it, and thus becoming specifically lighter ascend and give place to others. Thus heat is imparted constantly to fresh portions of the air, and carried off by them. If a hot body be suspended in a liquid, the process of its cooling is altogether produced

* Connexion of the Sciences, pp. 246, 247.

by this means, for in that case no radiation takes place, as in the instance of refrigeration in air."*

Thus we have seen by these concise but apposite passages, that not only would the cooling of the heated continents be accelerated by the aerial elements then present, but likewise that the oxydation of their metallic and metalloid components would, at the same time, be greatly facilitated by these having been introduced while in this condition, or rather thrust up while in this state, into the midst of waters abundantly saturated with free oxygen. The sudden and violent evaporation, from off the continents, of the water raised into steam by the intense heat of these intrusions, would occasion a rarefaction, at the same time, in the aerial portion of the atmosphere, which would cause an almost irresistible rush of wind, underneath, from the colder regions of the ocean towards and over the warmer lands; and, by this action, assist in producing the effect which next was designed, namely—to reduce the temperature of the terraine portion; and the more so, as these colder streams of air would be confined to the lower regions of the atmosphere, while they would accelerate oxydation, and prepare the oxydized mineral material, which is a necessary component of the soil that was so soon to be clothed with the vast variety and extent of those interesting objects, constituting the vegetable kingdom of the present day.

The effects of currents of air, both in a meteorological and a chemical point of view, are so influential in producing the combined results to which we now allude, that, except for the information of those who may not have given sufficient attention to the subject, we might have been spared bringing forward any evidences. The following brief quotations, from distinct sources of scientific research, will, however, tend to illustrate the consequences which would flow from the alternations of colder and hotter currents to which we have referred in the text:—

"There is a constant evaporation," observes Mrs. Somerville, "from the land and water all over the earth. . . . . In calm

* Heat, in Cab. Cyc. pp. 335, 336.

weather, vapour accumulates in the stratum of air immediately above the evaporating surface, and retards the formation of more; whereas a strong wind accelerates the process, by carrying off the vapour as soon as it rises, and by making way for a succeeding portion of dry air."*

"If air does not dissolve water," asks Mr. Donovan, "or exert any affinity on it, as is supposed by the hypothesis of Dalton, how does it happen that the evaporation of water is greatly promoted by passing a current of air over its surface? . . . . . I am inclined to think," he observes a little further on, "that the agency of both heat and affinity is necessary to the explanation of the phenomena. The increased solubility of air in water, in proportion as the latter is warmer, may be explained by the intensity of affinity; for heat is known in many cases to exalt its force."†

And from writers of meteorology we have the following concurring testimonies, as far as they are called upon to observe and record these vicissitudes:—

"When the wind blows from a cold towards a warmer climate," says Mr. Hutchinson, "the air, by communicating, with a progressive warmer surface, has its temperature and capacity for aqueous vapour more rapidly increased, than it is supplied with humidity by evaporation. . . . . The piercing and refrigerating influence, commonly ascribed to North and North-east winds in this island, is owing, not so much to their absolute thermometric coldness, as to their undersaturated state of dryness, and their consequently increased effort in abstracting heat from the human body, and from all other moist surfaces, by accelerating evaporation.

"When the wind, on the contrary, blows from a warm towards a colder latitude, and has its temperature slowly reduced by communicating with a progressively colder surface underneath, its capacity for aqueous vapour is simultaneously diminished.

"That the upper half of the atmosphere moves in the opposite direction to the lower, in the case of sea and land breezes, monsoons, and generally when the prevailing direction of the wind in the lower

* Connexion of the Sciences, p. 250.

† Chemistry, in Cab. Cyc. p. 150. In reference to this observation we must remark, that in the case in question, the heated condition of the water would augment the degree of affinity.

half of the atmosphere is from a cold towards a warm climate, can hardly be doubted.

"The atmosphere in a warm climate, by being expanded upwards, in consequence of the superior temperature, to a greater elevation than that in the colder climate, generates a current in the upper half of the atmosphere from the former towards the latter. . . . . This supplies air to the atmospheric columns over the colder districts, and increases the atmospheric pressure. Hence a counter current in the lower half of the atmosphere, from the cold towards the warm climate, is generated and maintained."*

"A current or high wind," says Dr. Thomson, "by disturbing the equilibrium of the molecules of the air, promotes evaporation."†

The Wisdom and Goodness which ordained, that those events should take place at the particular juncture recorded, are, likewise, most remarkable.

Had those violent and irresistible changes of temperature, or, in other words, the sudden rush of wind from the sea towards and upon the land, taken place *after* it was clothed with vegetation, the whole must inevitably have been rooted up, torn to pieces, and destroyed; while, at the same time, their existence, as a matted covering over the terraine surface, would have materially impeded the thorough evaporation of the water from off the land. These evils, however, were alike avoided by the completion, *beforehand*, of the three constituted elements which mutually contribute to the equable and healthfully moderate variations of climate which the world now enjoys—*the* ATMOSPHERE, *the* LAND, *and the* SEA. And it is with a satisfaction akin to perfect conviction, that we find the record of Scripture asserting, that it was precisely when the Wisdom, and the Goodness or Holiness of the Creator, or in other expressions, his natural and moral attributes were at one in willing those his formations, and the agents of his beneficence to his more sentient creatures, into existence, that they were brought forth; and that on reviewing them he could pronounce them to be "good."

With reference to the allusion which has just been made

* Principles of Meteorology, pp. 23, 94.

† Meteorology, p. 104.

to the combined agency of the three great natural bodies, the Atmosphere, the Land, and the Sea, as being conjointly essential to produce the delightful and wholesome vicissitudes of weather, so necessary for the well-being of the animated and the vegetable existences with which the surface of the globe is covered, we shall enjoy another most gratifying evidence of the surpassing wisdom of the Creator, when we investigate a little further into the manner in which the separation between "the waters" and "the dry land" was effected, and contemplate it with reference to the case in question.

We shall recognise in the fact of *vaporization and transference, by means of the atmosphere, having been employed,* one of the most soul satisfying proofs, that the Being who ordered it so, possessed a perfect power over all; and that the world was but as a ball in his hands, with which he, as a wise master-workman, did whatever seemed to him to be good.

It was formerly shown at great length, and with considerable care, that "the waters," after having been purified, by undergoing a process of deposition which continued through many ages of non-rotation, had, towards the close of that stage of the earth's existence, reached such a state of equilibrium, with respect to the saline and earthy ingredients which they held in chemical suspension, that no further deposition would have taken place; but in that condition they might have remained *ad infinitum,* had it not pleased the Creator to introduce the new principle of light, and, thereby, to impress rotatory motion upon the immense sphere over which they were spread out as a liquid envelope; and by means of the centrifugal impetus to break up its outer crust into continental ridges, insular elevations, and oceanic depressions. And, by the same and other forces, to expel from the primeval waters those free gaseous exhalations which formed the major part of the atmosphere. Whereby the earth, in place of having a concentric rock-bound surface universally covered by a liquid hollow sphere of equal depth, was transformed into the diversified and gorgeous world it now is, with its feracious lands, its sparkling, limpid seas, and, over all, its glorious azure canopy, each contributing to the perfection of the other; and, together, to the well-being of its numerous inhabitants.

We took considerable pains, likewise, to show, that the atmosphere is continually operating upon the ocean in such a way as to separate the pure water from its saline, acidulous, and earthy ingredients, over the whole surface of its almost illimitable extent; and, by means of certain meteorological phenomena, of which *wind* and *clouds* are very important essentials, to furnish the terraine portion of the earth's surface, or that which consists of land, with the requisite supply of moisture and fresh water. The vicissitudes of weather, which, in fact, are the verifications of those essential operations in nature, are so well known and so frequently observed by all, that further allusion to, or explanation of them are alike unnecessary.

But it may not so obviously occur to every one, that had the separation between "the dry land" and "the waters" *been effected by* DRAINING, *or by any other means than by* VAPORIZATION, *those necessary and salubrious interchanges between the water of the ocean and the land, by means of their connecting syphon, the atmosphere, would not have taken place with the same beneficial results.* This will be shown by recurring to the fact of the primeval waters having been purified to a condition of static equilibrium, which was designed to be maintained as the constitution of our present seas.* And inferring therefrom, that had that portion of the primeval waters which covered the continental ridges and other terraine elevations, been "gathered" *in its original condition,* into the great reservoir of the ocean, that is, in combination with all its saline, earthy, and acidulous ingredients, the aggregate mass *would have been precisely of the same description as were the original waters at the close of the period of non-rotation.* This is quite undeniable. And, consequently, there would have been no more water in the ocean than would have sufficed to have held the associated ingredients in chemical equilibrium. Therefore (supposing this to have been the case), every drop

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* By the *ninety-first* Theorem and evidences it will be seen, that wherever an axact analysis of the waters of the ocean have been made, they are found to consist of the *same ingredients,* and in the *same relative proportions,* the strongest proof of static equilibrium. Refer, in confirmation, to the *sixty-ninth* Theorem.

of pure water thereafter extracted from the broad expanse of the oceanic surface, by the evaporating influence of the heat of the atmosphere, and borne towards the land by means of clouds and winds, would have had the effect of precipitating the saline or earthy ingredient with which it had previously been combined, the remaining water, saturated to equilibrium, being quite incapable of sustaining the salt or the earth which would have thus been set free; and, from the same inability, those saline ingredients would have fallen to the bottom of the ocean—have been lost to the sustentation of animal and vegetable life for ever—and have been incapable of re-saturating the fresh water, which, from time to time, is restored to the general receptacle by means of rivers, rain, &c.

This return of water from the land to the ocean, poured into it from innumerable streams and rivers, being of lighter specific gravity and floating towards the surface, could not, under this supposed state of matters, have entered into re-combination with salts and earths, which had, during its absence, been precipitated to the bottom. The display of infinite Wisdom, which was put forth to provide for this apparently insurmountable double difficulty, is equalled, only, by the comprehensive simplicity and beneficence of the method adopted to guard against it, and to remove it entirely. The case stood thus: a level sphere—possessing an external crust of mineral material enveloped everywhere by a shoreless expanse of saline and acidulous waters—was to be transformed into a *terraqueous* habitation for man, animals, and plants, which should require occasional supplies of *fresh water*, by means of an atmosphere common to land and sea; and whilst the oceanic waters were to be maintained in their saline condition, a proportion of them was occasionally and universally to be made fresh for the continued supply of the beings and other formations which were to be willed into existence; the two kinds were, mutually, to act and react upon each other, so as each should be preserved in a state of healthful usefulness; and a MEASURE was to be found for that portion of the primeval waters which was to be made fresh. This appears to have been the complex problem which was to be experimentally

solved, and which was by the power and wisdom of the Creator successfully accomplished; as, indeed, we never could rationally suppose it would be otherwise.

Although, from the static constitutional condition which the primeval waters had attained towards the close of the non-rotatory period, they could neither dissolve nor chemically suspend more saline or earthy ingredients; yet *there was nothing in the composition of the mass to render an addition of* FRESH *water inimical to it.* On the contrary, the salts and earths could thereby be more effectually held in solution. A proportion of the water, then, was required to be made fresh. But how was it possible that part of an illimitable ocean should be made fresh whilst the residue continued salt? It was *not a reduction of the quantity* of original salt water covering the surface of the globe which was desired; but that, while *the entire aggregate quantity of water should remain the same throughout the earth, part thereof should be made fresh, and part should remain salt;* and that a *determinate scale of proportion* should be established between the one and the other; so that, while they existed in due balance, they should be allowed free intercourse with each other—the saline occasionally to act on the fresh—the fresh to produce its effects upon the saline

The first means adopted towards the accomplishment of this wonderful process, was to cause the earth to revolve around its axis. The next, to expand its surface and to corrugate it into continental elevations and oceanic depressions. Then, to deepen the mass of waters towards the equatorial regions by withdrawing them from the polar regions. Afterwards, to stretch out the firmament over both land and sea; to apply sudden and intense heats to that portion of the primeval waters which corresponded to the spaces occupied by the continents; and, by means of the different affinities for caloric which salts and earths have, when compared with water, to drive off the latter, in its vapourous state, into the new-formed atmosphere, and to leave the saline and earthy associates embedded in solid form in the earth.

No one can contemplate this mighty operation, in which

secondary causes were constrained by the Omnipotent to fulfil his wise and benignant designs, without being struck with the simplicity and grandeur pervading the whole! Every stage which the creation underwent, as it advanced towards completion, was immediately made an instrument, first, for the preparation, and afterwards for the accomplishment of that which was to follow. No example, of this kind, is more fraught with instruction than that which was shown forth by the separation of the surplus waters from off the land. Fresh water was not only formed by vaporization, and reunited in this state to the great remaining reservoir of saline water of the ocean, whereby this was for ever afterwards enabled to afford a supply of the same material for the future productiveness of the terraine portion, and for the uses of its inhabitants; but the saline materials, previously combined with the water so driven off, were left in solid store upon the land, where they could afterwards be easily obtained and applied to necessary purposes, while *the land portion of the earth itself* was employed as a standard whereby to mete out the quantity of fresh water to be poured into the sea; and thence to be taken again to irrigate the very land which measured it out from the primeval ocean!

The successful illustration of this part of our subject enables us to make the following observations:—

According to the Dynamical Theory—and to it alone—there were, at the period of the first rotation, intense *heats*, and enormous quantities of *saline material* to be accounted for.

As the elevation of the continental ridges and mountain chains was attributed to the diurnal *motion*; as *motion* inevitably occasions *friction*, and *friction* amongst material masses causes *heat*, and as the introduction of *heated mineral masses* into the midst of waters impregnated with *saline* ingredients, and especially when surmounted by an uncharged atmosphere, would assuredly cause *vaporization* and *separation* between the salts and their *aqueous* solvent; consequently, for all these reasons it was necessary, in order that no flaw might be left in this theory, to account for the expenditure of those fierce heats, thus raised, after they had been employed in fusing and charring the rocky masses themselves, in forming the veins,

and dykes, &c., and this we did by showing, that it was expended in vaporizing the aqueous portion of the atmosphere, and in separating and driving off fresh water, in the state of steam, from its saline associates over an extended area of not less than one-third of the entire surface of the earth. But this, true and natural as it is, only run us into another difficulty. For it showed, that there was a new and a vast accumulation—the solidified saline residia of this very vapourizing operation—to be accounted for.

In this dilemma the Record afforded us no further assistance than might be derived from the inference to be drawn from the guardedness of the expression employed in recording the command, "and let the dry appear"—not "the dry *land*," (as given in our versions, with as near an approximation as can well be made) but merely "the dry"—"and let the dry appear," which includes, besides the *land* properly so called, and of which the inspired historian was well aware, the immense formations of rock-salt, sal ammonia, gypsum, green-vitriol, nitre, natron, borax, saltpetre, and alum, and perhaps other substances which could not strictly be called *land*.

This inferential explanation, although it indicated, that in the case in question, *natural* causes had been allowed to operate in forming the "dry" portion; yet it was not sufficient to explain what had become of the saline residia which our Theory required should be accounted for, and we, therefore, turned to Geology for a more circumstantial elucidation. In doing so, we very soon found, that its indefatigable followers had, in the course of their researches, discovered immense deposits of these very saline materials of which we were in quest, but whose origin they were at a loss to explain. In fact, they could not account for them at all. We, of course, immediately laid claim to them as the *natural* results of the operation of those primary causes which this theory had been unfolding; while we offer the coincidence itself as a striking manifestation of *the soundness and sufficiency of the principles which have been laid down by us from the commencement.* For, when by them we are sent in pursuit of primary causes, or of anything which *natural* causes cannot produce, the Bible is our only guide, and our ready assistant; in it we invariably find them recorded

as the direct emanations of the Diety; but when we are in quest of such as arise solely from the operation of *secondary* causes, although in the sacred volume we can discover inferences, when it lends us very little direct assistance, we are necessitated to resort to the records of science, and there, as in this instance, we as invariably find what we are in search of; shown, at the same time, to be results of primary laws stamped on the pages of the Sacred Record.

We consider this a very opportune juncture again to direct the attention and to confirm the correctness of one of the assertions which lie at the groundwork of this theory, namely, "*that, in the narrative given of the creation in the first chapter of Genesis, a change of name always implies an alteration in the essential character of that which is so changed in designation.*"

In the particular case in question, the primeval waters being materially altered from what they were at "the beginning," by this abstraction of salt from them, or this influx of fresh water into them, required to be designated by another appellation; and their "*gathering together*" is called "*seas*;" whereas the earth, being the same as at "the beginning," is continued under the same designation, "And God called the dry *land* earth," a most significant fact, inasmuch as it not only shows the origin of the solid portion of the world, but also, that what was created as earth at "the beginning," remained so beneath the waters (although it could not be spoken of as dry land) until, by the introduction of diurnal rotation, it was elevated above the new level of the seas, where its first appearance obtained it the general denomination of "*dry*," in contradistinction to the *aqueous* portion by which it was surrounded, until it was finally named; when, no change of intimate nature having taken place, it was called "the earth" as at "the beginning."

That which we have just been exemplifying affords, likewise, a very remarkable corroboration of what we ventured to lay down at the commencement of our treatise, as another fundamental dogma of this theory, namely, that none of the several portions of the Creator's works were complete *until*, after having passed them in review, *he pronounced them to be*

"*good.*" Of those produced during the second day of the Mosaic week, not any of them was considered entitled to this; a term which may be received as recording their perfection. They appear to have been formed only to a certain extent, as if dependant upon that which was to follow, before they could be considered "complete and whole, lacking nothing." Such was the case with the *firmament*, even when transformed by partial completion into what was termed "the *heaven*" on the second day; in which peculiar condition it remained during a succession of day and night—by the rotation of the earth—and even until the land and sea were separated from each other on the *third* day; when the former standing out in bold relief with all its variety of hill and dale; the latter washing its new formed shore with its sparkling briny element; and the pure and healthful atmosphere, surmounting both, to enable the land and sea to act and react on each other, and together on their common canopy; then it was, but not until then, that all these three great divisions of nature were thoroughly completed; and God, in his infinite wisdom, saw fit to pronounce them "GOOD."

Now, when we turn to the records of philosophy to seek from the announcements of man for some explanation, why it was that there should have been, during the *second* and part of the *third* day, this remarkable withholding of the testimony by the Creator, as to the completion of the works of his hands, we meet at once with the most direct, though, perhaps, unconscious testimony to the correctness of our conceptions, and a clear and convincing explanation of the reason for this seeming exception; we find it therein asserted, that a mutual and intimate relationship subsists between the atmosphere, the land, and the sea; that these two last have, in turn, a reciprocal effect on the fluctuations and circulation of the atmospheric currents; and that, unitedly, they conspire to the health and to the existence of the animated beings and plants which inhabit the land and by which it is clothed; while the reverse of this aspect is equally as convincing, namely, that no combination of any two of these three great elemental bodies can produce any effect whatever, without the existence and assistance of the remaining one.

"The great instrument of communication," says Professor Buckland, "between the surface of the sea and that of the land, is the atmosphere, by means of which a perpetual supply of fresh water is derived from the ocean of salt water, through the simple process of evaporation. By this process water is incessantly ascending in the state of vapour, and again descending in the form of dew and rain. . . . . . As soon as springs issue from the earth, their waters commence their return towards the sea; rills unite into streamlets, which, by further accumulation, form rivulets and rivers, and, at length, terminate in estuaries, where they mix again with their parent ocean. Here they remain, bearing part in all its various functions, until they are again evaporated into the atmosphere, to pass and repass through the same cycles of perpetual circulation."*

"In the adjustment," says the same author, "of the relative quantities of sea and land in such due proportions as to supply the earth by constant evaporation, without diminishing the waters of the ocean; and in the appointment of the atmosphere to be the vehicle of this wonderful and unceasing circulation; in thus separating these waters from their native salt (which, though of the highest utility to preserve the purity of the sea, renders them unfit for the support of terrestrial animals or vegetables), and transmitting them in genial showers to scatter fertility over the earth, and maintain the never-failing reservoirs of these springs and rivers, by which they are again returned to mix with their parent ocean; in all these circumstances we find such evidences of nicely balanced adaptation of means to ends, of wise foresight, and benevolent intention, and infinite power, that he must blind indeed, who refuses to recognize in them, proofs of the most exalted attributes of the Creator."†

"Climate, in its wider sense, observes Professor Whewell, "is not one single agent, but is the aggregate result of a great number of different agents, governed by different laws, producing effects of various kinds. The steadiness of this compound agency is not the steadiness of a permanent condition, like that of a body at rest; but it is the steadiness of a state of constant change and movement, succession and alternation, seeming accident and irregularity. It is a perpetual repose, combined with a perpetual motion; an invariable average of most invariable quantities. . . . . . The principal constituents of climate are, the temperature of the earth, of the

* Bridgewater Treatise, vol. i. pp. 557, 558.

† Vindici Geologici, p. 13. Also Bridgewater Treatise, vol. i. pp. 570, 571.

water, of the air, the distribution of the aqueous vapour contained in the atmosphere, the winds and rains, by which the equilibrium of the atmosphere is restored, when in any degree disturbed."*

And, at another part of his Treatise, he says—

"Hence, it follows that the ocean, which covers so large a portion of the earth, and affects the temperature of the whole surface by its influence, produces the effect of making the alternations of heat and cold much less violent than they would be if it were absent. The different temperatures of its upper and lower parts produce a current which draws the seas, and, by means of the seas, the air, towards the mean temperature."†

And again—

"The coldness of the atmosphere, and other causes, precipitate the moisture in clouds and showers, and in the former as well as in the latter shape it is condensed and absorbed by the cool ground. Thus a perpetual and compound circulation of the waters is kept up; a narrower circle between the evaporation and precipitation of the land itself, the rivers and streams only occasionally and partially forming a portion of the circuit; and a wider interchange between the sea and lands which feed the springs, the water ascending perpetually by a thousand currents through the air, and descending by the gradually converging branches of the rivers, till it is again returned into the great reservoir of the ocean. . . . . . A due distribution of these circulating fluids in each country appears to be necessary to its organic health, to the habits of vegetables, and of man. We have every reason to believe that it is kept up from year to year; as steadily as the circulation of the blood in the veins and arteries of man. It is maintained by a machinery very different, indeed, from that of the human system, but apparently as well, and, therefore, we may as clearly say, as that adapted to its purposes.

"By this machinery we have a connexion established between the atmospheric changes of remote countries. . . . . . The properties of water with regard to heat, make one vast *watering-engine* of the atmosphere."‡

"We may observe," he continues, "that the aerial atmosphere is necessary as a vehicle for the aqueous vapour. Salutary as is the

* Professor Whewell's Bridgewater Trêatise, pp. 75, 76. † Ibid, p. 81.
‡ Ibid, pp. 83—85.

operation of this last element to the whole organised creation, it is a substance which would not have answered its purposes if it had been administered pure. It requires to be diluted and associated with dry air to make it serviceable."*

"It would be probable, from this reflection alone, that, in determining the quantity, and the law and interstices of earth, water, air, and heat, the same regard has been shown to the permanency and stability of the terrestrial system, which may be traced in the masses, distances, positions, and motions of the bodies of the celestial machine."†

Perspicuous and satisfactory as the preceding observations are, we cannot refrain from noticing, that their substance has been summed up and expressed, ages ago, in one brief sentence by the wisdom of the Preacher:—

"All the rivers," says he, "run into the sea; yet the sea *is* not full: unto the place from whence the rivers came, thither they return again."‡

There is another passage of Scripture so illustrative of the action and reaction of the elements on one another, and their immediate connexion with God, their common Creator, that although figuratively employed, we cannot refrain from quoting it:—

"And it shall come to pass in that day," says Hosea, "I will hear, saith the LORD, I will hear the heavens; and they shall hear the earth; And the earth shall hear the corn, and the wine, and the oil; and they shall hear Jezreel. And I will sow her unto me in the earth; and I will have mercy upon her that had not obtained mercy; and I will say to *them which were* not my people, *Thou art* my people; and they shall say, *Thou art* my God."§

And at another place it is said:—

"Therefore the heaven over you is stayed from dew, and the earth is stayed *from* her fruit."||

Thereby showing that dew is *the fruit* of the heavens.

Several meteorological writers, struck with the wonderful

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* Professor Whewell's Bridgewater Treatise, p. 97. † Ibid, p. 109.

‡ Ecclesiastes, i. 7. § Hosea ii. 21—23. || Haggai i. 10.

adaptation of the elements, have expressed themselves in becoming terms of admiration and thankfulness, when they contemplated the wise and the benignant arrangements which have been made, by the machinery of the weather, for the well-being of creation.

"The rainy season," says Mr. Hutchinson, "is obviously a providential arrangement in creation to serve a useful purpose. Clouds, during its continuance, moderate the warmth, by acting as screens to intercept the scorching rays of a vertical sun, while the temperature of the earth is further mitigated by the descent of rain, and by evaporation from its moistened surface. Thus, we see, that the rains, which are indispensably necessary in order to vegetation, occur in accordance with the prospective wisdom and beneficence manifested in all the other arrangements of nature, at the season of the year when their cooling influence is most required.

And again, when treating of dew, he observes:—

"In consequence of dew resulting from the depression of temperature, arising from radiation, it falls most copiously on those places where the surface of the ground is best fitted for radiating caloric. Hence, agreeably to the beneficent designs of Providence, by which scarcity produces proportionate economy, and by which all phenomena are adapted, upon the wisest principles, to serve useful purposes, frugality in its distribution is observed to be proportionate to the smallness of its quantity." . . . . .

"This fluid," says Dr. Wells, "appears chiefly where it is most wanted, on herbage and low plants, avoiding, in great measure, rocks, bare earth, and considerable masses of water. Its production, too, by another wise arrangement, tends to prevent the injury that might arise from its own cause; since the precipitation of water upon the tender parts of plants, must lessen the cold in them that occasions it."*

"Clouds," says Dr. Prout,† "are one of the great means by which water is transported from seas and oceans to be deposited far inland where water would otherwise never reach. Clouds also greatly mitigate the extremes of temperature. By day they shield

* Dr. Wells's Essay on Dew.

† Bridgewater Treatise.

vegetation from the scorching influence of the solar heat; by night, the earth, wrapt in its mantle of clouds, is enabled to retain that heat which would, otherwise, radiate into space, and is thus protected from the opposite influence of the nocturnal cold. These benefits arising from clouds, are most felt in countries without the tropics, which are most liable to the extremes of temperature. Lastly, whether we contemplate them with respect to their form, their colour, their numerous modifications, or, more than all, their incessant state of change, clouds prove a source of never-failing interest, and may be classed amongst the most beautiful objects in nature."*

These conclusions, so illustrative of the operations which it pleased the Omnipotent at that time to perform in the development of the plan of creation; the distinct and prominent separation of the land from the sea; and the stretching forth of the atmosphere over both, these, acting on each other to produce the wholesome and essential vicissitudes of weather, and the necessary recurrence of warmth and moisture, conspire unitedly *to determine the precise period of their common origin.* To produce these results, it was absolutely essential that a *sphere,* covered with *saline water, should be put into rotatory motion. None but these conditions could have been attended by the resultant consequences which we now experience.* A non-rotating sphere only could have been *everywhere* covered with water.† The water which everywhere covered a sphere could only have been of *one* kind. That which primarily enveloped the earth could *not* have been without saline materials. Of this we are assured by reasoning *a priori,* and confirmed by the senses; for, had it been *free* from these, there could not have remained any saline deposits in the terraine portion; nor could the present saline condition of the oceans have been accounted for; while the character and composition of the deposits prove, that the portion of water which corresponded to that part which is now land, if not actually saline, contained saline elements; consequently, if one part was of this description, the *whole* of the primeval water which enveloped the

* Principles of Meteorology, pp. 146, 177, 222, 223.

† *First* and *tenth* Theorems and their evidences.

non-rotating sphere, having been all of one kind, must of necessity have likewise been impregnated with salt.

*The original water, therefore, which surrounded "the earth" at "the beginning," we conclude did contain the elements of salt in association with itself.**

The only method known of producing a thorough and sudden separation between water and its saline associates, is by the application of heat to the mixture. But, "as the same causes produce the same effects," had the heat been *equally* applied to the *whole* of the ancient waters, an entire separation between them and their saline associates would have taken place alike over land and sea. The separation, however, was partial; and so surely as it *did not* take place to any extent, in those portions of the waters which constitute our present seas, so surely *did* it take place in those which surmounted at one time the continents and other prominent parts of the earth, for, *in these latter there still remain, deeply imbedded in the soil, solidified deposits of precisely the same saline description, which, by their union with the vast aqueous reservoirs of the ocean, communicate to them their distinctive saltness;* and preserve them in their destined condition of salubriousness and utility.

This brings us to a point which shows, that to the universally encircling mass of saline water which accompanied the non-rotating earth, heat of sufficient intensity and extent, was applied *partially;* whereby part was rendered *fresh*, by being driven off in aqueous vapour, leaving behind its saline associates, while the major part remained in combination with those ingredients; and we know of no cause commensurate to this stupendous, yet discriminating effect, save the friction produced by the elevation of continents and mountain chains thrust up from beneath; and, even in many instances, along with the stratified mineral masses which formed the spherical crust of the earth, by the centrifugal impetus occasioned by the protorotation of our planet around its axis. No secondary cause, short

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* In a previous part of our work we have endeavoured, and we trust succeeded, to make apparent the difference between our present "seas" and water holding saline and earthy elements in solution.—AUTHOR.

of this, can be adduced as at all sufficient for this great undertaking. While this supplies the measure required, being fully commensurate thereto; we may, therefore, conclude, that the formation of the atmosphere, and the separation between the dry land and the sea, took place while as yet the influence existed of the centrifugal impetus, occasioned by the first rotation of the earth around its axis. This involves, as a necessary corollary, *that there was a period, however evanescent, when the world was not impressed with diurnal motion;* which being once admitted —and after what has been said we do not see how it can be denied—it may as consistently be conceded, that the sphere existed in its non-rotatory condition for a period, whose duration was sufficient to accomplish that which its want of diurnal motion was intended to produce; quiescent tranquillity being one of the most essential requisites for the promoting of stratification. And as the mineral masses, whose movement caused the friction, which evolved the heat necessary to drive off the fresh water from the sedimentary salts found associated with the red sandstone, oolitic, and other kindred formations; as well as the nitrogen required to form the atmosphere, and the peculiar material, whatever it be, required to constitute the etherial fluid,* were the products of the accumulation of a succession of ages; we have, by this convergent approach, reached the same common and comprehensive deduction, as by all our previous lines of argument, namely, *that the earth revolved around the unillumined sun for a long but indefinite period before rotatory motion was impressed upon it.*

We shall continue the present chapter by directing the attention to the further use which was made of the new-formed atmosphere, in nourishing and sustaining the numerous and diversified objects of the vegetable kingdom, with which it pleased the Omnipotent Creator to clothe and to embellish the naked "dry land," thus brought out in such bold relief from "the seas," which were then gathered into one place

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* Dr. Thomson, when treating of this attenuated elastic fluid, says, "shall we seek for the cause of this celestial temperature in the presence of an etherial fluid, *sui generis*, existing above our atmosphere and pervading space? Of such a fluid, however, we possess no positive knowledge." (Page 72).

within their assigned and predetermined limits; when "He shut up the seas within their bounds, that they should not pass over."

The third section of this work having been so exclusively dedicated to a kindred branch of this subject, and our views having been therein so fully unfolded, as to those classes which *are*, and those which are *not* considered, by us, to have been willed into existence during the *non-rotating* period of the earth, our present observations will be applicable only to the *flowering* or *phanogamous* plants of the vegetable kingdom, which were formed during the Mosaic week, and, of course, what we state will assume a corresponding character, for we shall have to bring forward views and data which shall be the very opposite—in the state of matters now—from what then obtained. Formerly we had to treat of plants deprived of flowers, seeds, or fruits properly so called, and all around was in conformity. Now all these are superadded, and the condition of creation having undergone a corresponding change, our observations will have to partake of this change also.

The first points to which the attention has to be directed, are the appropriateness of the juncture at which this great division of the vegetable kingdom was called into existence; and the adaptation of the elements, then existing, to its formation. It being assumed, *that when a work of this kind is delegated to any agent*—as this was to the earth*—*the means to carry it into effect would be duly provided, and placed by the Creator at the disposal of that agent;* likewise, *that the concomitant circumstances would be auspicious for the performance of the command.*† The state of the earth, at the period when the divine historian records that the *phanogamous* part of the vegetable kingdom was willed into existence, will satisfy us that this assumption is correct. The component elements of almost all the organized objects which constitute the vegetable kingdom, may be reduced to three ultimate principles, namely, hydrogen, oxygen, and carbon. Of these,

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* Genesis i. 11, 12.

† This, which is a fundamental assumption of our theory, has already been proved to be a sound one.

together with a few peculiar salts in small quantities, and of a minute proportion of nitrogen found in some peculiar families, the whole of those interesting, varied, and useful objects of nature are entirely composed.*

The two first of these elementary and necessary ingredients were abundantly provided for by the aqueous vapour with which the atmosphere was saturated, in the manner we have so lately explained; while the carbon, the remaining essential requisite of the vegetable kingdom, would be plentifully supplied by the carbonic acid, liberated by heat from the fused masses of limestone intermixed in the rocky elevations which had been thrown up to form the terraine portion of the globe; the associated lime having been disengaged, to assist in composing the soil which was deputed to produce them. For it will be seen, by referring to the *hundred and second* Theorem, that the application of fierce heat to the carbonate of lime, or common limestone, disunites the calcareous earth from its acidulous associate, both of which, in this instance, were useful, indeed could not be dispensed with. And thus we find, that the provident wisdom of the Creator had provided all the materials which were required before he issued the command—"Let the earth produce grass; the herb yielding seed: and the fruit tree yielding fruit, whose seed is in itself upon the earth." Indeed such are the leading characteristics of this theory, that unless some vast operation, such as the embodying of the whole phanogamous division of plants had been undertaken, we should have been utterly at a loss to have accounted for the extra carbonic acid which abounded at that particular period.

But we have still to unfold, with peculiar satisfaction, though in brief detail, circumstances which point in a peculiar manner to the appropriateness of the *juncture* when it pleased Him, who is possessed of the most consummate wisdom, to will into existence the flowering, seeding classes of the vegetable kingdom, which are recorded to have been formed at this time. We have seen that the requisite materials were prepared in

* Edinburgh Journal of Natural History. Murray's and Reid's Chemistry. And Todd and Bowman's Anatomy of Man, &c. &c.

great abundance and held in readiness; and we have now to be made aware, that a great receptacle for them, and a suitable means for their ready conveyance, were also provided. *This was the new-formed atmosphere*, peculiarly well fitted, both by its nature and universality, for maintaining in immediateness the aqueous vapour and carbonic acid wherever plants were to be formed by the delegated command which the earth had just received. Next, the vegetable kingdom was called into existence while as yet the light and heat—the principal agent in fixing the woody fibre—was *not concentrated* around the sun, or constituted as it is at present; for in *that* case it could not have supplied the quantity of light requisite for this operation *within the time specified*, as we intend presently to show; while, for other and very essential reasons, we are particularly desirous that it should be clearly borne in mind, that the light which was employed in conferring vegetable vitality was *different in kind* from that which afterwards was employed in forming the animal kingdom, and supplying *its* stream of nervous fluid. And, lastly, the creation of this kingdom of organic objects was with as much wisdom and goodness *deferred* until this particular juncture, as it was most benignantly interposed between the formation of the continents and that of the animated beings destined so soon to follow. Because, in the elevation of the former, during which there was so much carbonate of lime present, and so much heat evolved by friction, the extrication and suffusion of immense quantities of carbonic acid were wholly unavoidable, and would assuredly have proved prejudicial, if not positively destructive, to the lives of the creatures constituting the animal kingdom, had not the vegetable forms preceded them; towards whose formation that pungent and life-destroying gas is as favourable and conducive as it is prejudicial to *animal* existences. Adopting, in this view of the subject, the words of Professor Whewell, we may say—

"That in such cases, we conceive we trace a Creator who, in producing one part of His work, was not forgetful or careless of another part; and who did not cast his living creatures into the world to prosper or perish, as they might find it suited to them or not, but

fitted together, with the nicest skill, the world and the constitution which he gave to its inhabitants; so fashioning it and them, that light and darkness, sun and air, moist and dry, should become their ministers and benefactors, the unwearied and unfailing causes of their well-being."*

Dr. Thomson, when alluding to an earlier epoch of the earth's history, refers to a speculation of Mons. Adolphe Brongniart upon "the formation of the carboniferous beds, which are so widely distributed over our globe, and without which civilization would not have rapidly advanced," and employing the language of his authority, he goes on to say—

"To M. Brongniart it has occurred, that during that era the atmosphere was much more largely charged with carbonic acid gas than now or previously.

"There seems to have been an ascendancy in the vegetable over the animal kingdom, for while immense numbers of trees and arborescent ferns and smaller plants existed, scarcely a vestige of land animal is to be found.

"If we suppose, that during that period there was a larger proportion of carbonic acid in the air than now, it would be most favourable to vegetable life, while the excess would be detrimental to animal existence.

"No sooner were those vast coal-fields deposited, than we find a manifestation of animal life, and finally its predominance.

"We find much luxuriant vegetation in the presence of these waters, which are richly charged with carbonic acid gas."

Gratified by thus encountering men, pursuing such distinct branches of science, who alike testify to the generally admitted assumption, that the constituent period of the earth's early history was likewise one in which carbonic acid gas abounded to excess, we have offered the passage as it is given by Dr. Thomson; although we must disclaim any intention to adopt the untenable conclusion to which the authors quoted seem to have come, namely—that this pungent and plant-sustaining gas was contained "in the air" at that period.

It was held in chemical suspension by a body much better adapted for imbibing it in great volume: the primeval ocean.

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* Bridgewater Treatise, pp. 19, 20.

"The air"—even had the atmosphere existed coevally, but which was not the case—could not have suspended the quantity required for the growth and maturation of the infinite numbers of those gigantically proportioned flowerless plants, whose carbonized remains constitute the combustible material of the coal-measures, although this objection does not apply to the phanogamous classes, in the altered condition of the earth. And thus every testimony borne to the actual state of the organic kingdom, during the period to which we allude, strengthens and confirms the belief we entertain in the Dynamical Theory, and in the announcements of Scripture on which it is chiefly based.

In continuing our subject, the first thing to which we shall direct the attention, while we endeavour to establish it from the writings of botanical physiologists, is, that there must have been a decided difference of character between the plants which were willed into existence by the Creator, by means of the command we have lately been perusing, and those which had been formerly created, during the non-rotatory period, for the advancement of his wise designs; because atmospheric air, which did not exist until then, is essential for the growth and perfection of innumerable orders of plants, which could not, it is presumed, have existed before the completion of what was so essential to their well-being. With this view, let us recapitulate the *hundred and eighteenth* Theorem, "*That all the phenomena attending the flowering of plants, and the dehiscence of the various receptacles which are instrumental in the fertilization and maturation of the seed and fruit, and the dissemination of the former, fully attest the absolute necessity of these complicated operations being conducted in atmospheric air; the presence of much moisture being prejudicial to the peculiar development of the pollen.*" And, in continuation, we adduce what is stated in the succeeding Theorem; "*That immediately after the flower has become fully expanded, some portions of it begin to decay; but the ovarium and sometimes the calyx, and other parts continue to grow, and assume a very different appearance—they become the fruit; while the ovula having been subjected to the fertilizing influence of the pollen, also undergo certain remarkable changes, and become the seed.*

"That these fruits, thus enclosing their seeds, assume a great variety of forms and characters, some being soft and pulpy, others hard, woody, dry, and membranaceous; but, in general, they may be classed under some one or other of the following denominations, namely:—the legume; the drupe; the nut; the akenium; the glans; capsule; gourd; berry; pome; samara; or the siliqua."

Those truths are so apparent, that nothing but the characteristic of this work—exactitude—could have induced us to have brought them forward; and leaving it, therefore, to those who may have any remaining doubts, to look into the coincidence of the evidences quoted in support of these theorems, we shall proceed to make the application for which they were adduced, in support of the general argument. It is this, that as the leading difference between the phanogamous plants—comprising the classes monocotyledons and dicotyledons—and the cryptogamous plants or acotyledons, consists in the two former possessing flowers and perfect seeding apparatus, while the latter is destitute of both; and atmospheric air being indispensably requisite for the growth and perfection of Flowers, Seeds, and Fruits, it follows, as a clear deduction, that plants of the *phanogamous* kind could not, by any possibility, have existed previous to the formation of the atmosphere. And as the atmosphere, according to what we have now explained, could not have existed before the formation of the light, and and the revolution of the earth around its axis, it follows, as a matter of course, *that phanogamous plants could not have existed previous to the diurnal rotation of the earth.* But we have made it as apparent as the evidences of the senses will permit, that long previous to the formation of the atmosphere, to the calling forth of the light, or to the rotation of the earth around its axis, the sub-aqueous surface of our planet abounded with plants. By the dexterous blending of these two classes of truths, it follows, that those which primarily existed, *were not flowering plants;* and if not flowering plants, they could neither have produced seeds, nor fruits with seeds in themselves; because to produce seeds, or fruits with seeds, flowers must precede; and if destitute of seeds, they were not included in the last command issued on the third day, because all the

plants mentioned in it were either to produce seeds, or fruits with seeds in themselves. And thus we have the word of God, as communicated by His inspired amanuensis, alike consistent with itself in all its various parts; and perfectly in accordance with the existing laws of nature, as manifested to us by the announcements of natural philosophy in its several ramifications.

This leads, in turn, to a well-grounded presumptive inference, that as light and atmospheric air exercise their influence principally on the floral envelopes of plants, and on the seeds and fruits, which, in due course of time, proceed from these interesting and beautiful vegetable expansions, we may thence conclude, that the plants of the non-rotatory period were deficient in these peculiar organs. Light and atmospheric air not then existing, they could not have been brought to perfection. And, that although it is still a very important desideratum in botany to determine which families of plants are, in reality, *seedless*, yet it must be inferred, that such as are or were so, were known to the inspired historian to have existed previously to the formation of the flowering classes; inasmuch as he expressly mentions the *creation of the earth*, and this, we know proceeded in part from their secretions and their fossilized remains.

We shall now, in prosecution of our argument, direct the attention to an enumeration of the principal elements which contribute to the formation of vegetable textures, especially to those which are essential for the construction of woody fibre. With this intention we shall recapitulate the *forty-fourth*, and afterwards the *hundred and twenty-fourth* Theorems, both of which are relevant to the same subject; and, in continuation, we shall adduce such evidences as are common to both, and bear directly on the point we are desirous to substantiate. The former states:—

"*The quantity of water lost to a plant by evaporation, and its power of absorption from the soil are in proportion to the quantity of light. Light causes the decomposition of the carbonic acid of vegetation; and, by solidifying the tissue, renders the parts most exposed to it the hardest. And the green parts of plants, when exposed to the direct light of the sun,*

absorb from the atmosphere carbonic acid, which they decompose, and give back the oxygen.

The *hundred and twenty-fourth,* nearly to the same effect, states, "*That besides the carbonic acid elaborated by plants within themselves by means of the oxygen imbibed from the atmosphere, and by the carbonaceous matter contained in their sap, they absorb it also from the air, and receive it combined with the water taken in by their spongioles; and that so long as plants remain in the dark, the greater part of the carbonic acid is retained, but not fixed in the form of an organic compound until stimulated by the light, when its decomposition is effected; the carbon becomes fixed, and nearly all the oxygen with which it was united is exhaled into the atmosphere.*"

Having, in the third section of this work, gone fully into the physiology of certain parts of plants, we shall, on the present occasion, when adducing the conjoint evidences for these theorems, dwell more particularly on those affecting the point we seek to establish—the fixation of vegetable matter, and the formation of textures peculiar to the objects of that kingdom of nature.

"When the food of a plant enters the roots," observes the writer on Botany, in the Cabinet Cyclopedia, "it passes upwards, undergoing some kind of chemical change, and dissolving whatever soluble matters it meets with in its course; so that, without having been exposed to any of those conditions by which it is ultimately and principally affected; it is considerably altered from its original nature before it reaches the leaves. . . . . . A portion of the water which plants suck up combines with the tissue, and enters into the general constitution, where it becomes fixed as the water of crystallization in minerals. . . . . . Under what influence, except that of the vital principle, a decomposition of the sap takes place before it reaches the leaves, we are ignorant. But when it has reached the leaves, and thus becomes exposed to the effect of light, ... *we find that light causes a decomposition of the carbonic acid of vegetation, and consequently, by solidifying the tissue, renders the parts most exposed to it the hardest.* . . . . . That the quantity of water lost to a plant by evaporation is in proportion to the quantity of light is easily proved by the experiment mentioned by De Candolle. . . . . . Whatever doubt there may be concerning the

precise causes of evaporations, there can be none whatever as to the power which sunlight has to cause the decomposition of carbonic acid, the fixing of the carbon, and the giving out of oxygen. . . . . For, however varied experiments may be, they all lead to the same result, and compel us to acknowledge the great importance of light to plants, in enabling them to digest the crude matter which they gain from the soil. In fact, there is nothing of which we have any certain knowledge that interferes with these conclusions."*

"When all those parts of plants," according to Professor Henslow's popular treatise, "which are capable of assuming a green tint, but more especially the leaves, receive the stimulus of light, they immediately decompose the carbonic acid contained in the sap. The result of this action is the retention of the carbon, and the expiration of the greater part of the oxygen into the surrounding atmosphere. . . . . . The fixation of the carbon by plants appears to be the first step in that elaborate process by which brute matter is converted into an organizable compound; that is to say, into a material capable of being afterwards assimilated into the substance of an organized body. Many effects, popularly ascribed to the action of air, are, in fact, due to the agency of light. . . . . . When we proceed to enquire in what form the carbon appears after it has become fixed, the subject assumes a degree of uncertainty, which it seems almost hopeless to get rid of in the present state of our knowledge. . . . . . Unluckily for our enquiry, there are so many different compounds contained in solution among the sap and various juices of plants—such as gums, sugars, resins, oils, acids, alkaloids, &c., all of which are composed of different modifications of the same three elements, carbon, oxygen, and hydrogen—that it becomes a task of the greatest delicacy to determine which of them ought to be considered as the immediate result of the process of fixation. . . . . . But we find, upon more careful enquiry, that our choice is restricted to about four substances, all of which possess nearly the same chemical characters, and which are the most universally present among the juices of plants. These are gum, sugar, fecula, and lignine. The first of these appears by far the most universally diffused, and has been obtained from nearly every plant in which it has been sought for; and, moreover, as it possesses decidedly nutritious qualities, it may be considered, with every probability in its

* Botany, in Cab. Cyc. pp. 84, 85.

favour, as the first or proximate organizable compound, formed by the action of vegetable life, acting under the stimulus of light."*

Having been informed, by these evidences, what are the elements which enter into the construction of plants, and the manner in which they are solidified by the effectual influence of sun-light; the scope of our argument constrains us, before we conclude this chapter, to direct the attention to seemingly a very homely and well-attested truth, declared in part of the *hundred and twenty-first* Theorem, namely, "*that the time required to admit of plants arriving at maturity varies from some weeks to several years.*"

As this is a fact so completely known to all—and writers on botany have seldom occasion to refer to it except by assumption—it must either be admitted, merely on the authority of the theorem, or proved by the duration, or by the assumed period for the maturation of the several orders and genera of the phanogamous classes of plants throughout the world. We shall rely on the former method of authenticating the assertion; being convinced, that it coincides so closely with the experience of all who are in any manner conversant with botany or horticulture, as to require nothing beyond its mere enunciation to be taken for granted.

The period, then, required to mature the objects of the vegetable kingdom, is never shorter than several weeks; and in numberless instances is prolonged to as many years; and we beg that this fact, although trite and commonplace may be borne in mind, as we shall require to lean pretty heavily upon it, in our immediately subsequent reasoning.

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* Botany, in Cab. Cyc. pp, 189—191.

SECTION VIII.

COMPLETION OF THE ATMOSPHERE; SEPARATION OF THE SEA FROM THE LAND; AND THEIR IMMEDIATE COMBINED RESULTS.

CHAPTER XXXV.

Application of the subjects which occupied the attention in the preceding chapter. Supernatural action of Light in and during the formation of the Phanogamous division of the Vegetable Kingdom. Reflections which this display of great power necessarily occasions. This chain of reasoning confirmed by quotations from Botanical writers. Further evidences in favour of the Dynamical Theory deducible from the existence of distinct Botanical districts throughout the earth's surface. Scientific confirmation of these assumptions; and the regions defined in which the phanogamous classes abound. Combination of these truths with those formerly wrought out, applied to prove that the Earth, in perfect accordance with this theory, received from the hands of the Creator, on the first day of the Mosaic week, the identical inflexions of surface which it still retains.

CONSIDERING the mind to be properly instructed with respect to the two distinct subjects which occupied our attention towards the close of the preceding chapter, that is to say—the ponderable and imponderable elements which enter into the composition of vegetable texture and woody fibre; together with the manner and process of their acting on each other, and of being elaborated into these forms; and, on the other hand, the usual time required to bring the objects of the vegetable kingdom to perfection and productiveness; we shall, now, in continuation, endeavour, by their careful combination, to elicit another important truth, namely—that to enable the earth to produce and bring to perfection the whole of the vegetable forms, which clothe and adorn its surface, in the brief period of one day, there must have been a *supernatural* power

conferred upon it; an *extraordinary* supply of material placed at its disposal; and, likewise, a commensurate suffusion of light and heat communicated; to the intent, *that the vast provision of material, thus made, should be decomposed, assimilated, and fixed into the form and substance of full grown herbs and fruit-bearing trees, within the time specified.*

Perhaps, this may be thought rather an advanced position to be adopted on the part of a creature, as if tending to circumscribe, by attempting to reduce to the standard of our puny conceptions, the ways and the workings of a BEING whose every direct act is, and must ever be essentially supernatural; and, consequently, not capable of being limited by our conceptions. A charge of this nature can scarcely, however, be substantiated against us; considering that we have dedicated years of intense and continued thought, and of earnest supplication, to render the truths of philosophy instrumental in exalting the Scriptures to the rightful supremacy from which they have been too long deposed; and whose mental energies have been so strengthened by the endeavour, that we find ourselves in a frame of mind, alike removed from the scepticism which would dare to rob the Deity of the minutest of his attributes, or attempt to conceive limits to His power; and from that false delicacy which would shrink from taking a calm, deliberate, and stedfast view into the works and mysteries of the creation, as far as they are revealed or exhibited to our senses and for our information.

"Secret *things belong* unto the LORD our God: but those *things which are* revealed *belong* unto us, and to our children for ever."

Impressed, therefore, with the conviction that *faith is not incompatible with observation and common sense, when employed in the contemplation, and in the reconciliation of the Record with the works of creation,* and fully convinced, that when laws are once established by the Creator, they are ever afterwards respected by Him; and taken into account in all that he does *subsequently* to their promulgation; we can

* Deuteronomy xxix. 29.

clearly apprehend, that when it was deemed necessary *to delegate to the new formed earth* the miraculous faculty of bringing forth the phanogamous or flowering part of the vegetable kingdom, at once and in perfection—we may dismiss from our minds any misconception which would arise from an attempt to impute a mystical meaning to these words; but reposing in perfect confidence on the spirit which pervades this part of Scripture, and looking upon the objects which were produced in their true acceptation, as the stock or progenitors of all the orders of the flowering, seeding, or fruit-bearing plants—the *material, tangible objects* of the phanogamous division of the vegetable kingdom, we conclude, clearly and decidedly, that although the power to produce them was *supernaturally*, and only for once conferred on the earth, and the elements then present were in *quantity preternaturally* brought into juxtaposition, yet the materials themselves were *natural*, were produced by natural agents, or elements so *made to abound*, as they then were, and for that *special occasion*, never afterwards to be repeated. Having, by a similar process of reasoning, been enabled to satisfy our mind, that sources sufficient to yield these extra supplies of hydrogen, oxygen, and carbon, did exist at the time alluded to, we become, likewise, convinced, that there was a source from whence there could emanate a greater supply of LIGHT and HEAT than now comes in one day, or in a part of a day, from the sun; and which being required, was sufficient to work up these materials. Therefore, although we will not err against our convictions, and assert that God could not, by an effort of his sovereign power, have willed that the light now communicated in the usual recurrence of one day should have effected that purpose, and have enabled the earth to combine the materials placed at its disposal for the production of the *phanogamous plants;* yet we persist in affirming, that, on the occasion which we are now contemplating, *it did not please Him to do so.* And we trust to prove, in the most satisfactory manner, in the sequel, that the quantity of light employed in producing and perfecting the vegetable kingdom, on the third day of the Mosaic week, *was supernatural,* and that it has never been so communicated again, since the

remainder of the light has been concentrated around the sun, in order to be imparted to the planets of the system in *quantities* whose amounts can be computed by the *time*.*

To confirm us in the assumption we have ventured to make —that it was an application, and an effect of the primary light before it was concentrated around the sun—in the extraordinary quantity required, which wrought up the vegetable elementary matter then made to abound for the purpose, we have, first of all, to consider generally, that the expansive principle of light was that which the Omnipotent seems chiefly to have employed during the whole period designated as the Mosaic week. It was the electro-magnetic influence, and energy of light, which was used to cause the earth to revolve around its axis, and to occasion the first night and day. It was its expansive principle, which, united to the pre-prepared elements, caused the firmament to be stretched forth as a garment; the same subtile and buoyant power, when combined with the aqueous elements, dispersed the necessary vapour throughout the heavens; and it also was light which effected the separation between the land and the sea. From the evidences of modern botanists, we have seen, that it is, even now, light and heat which are chiefly instrumental in forming and consolidating vegetable fibre and texture; and we must never for a moment forget, that it is not because it does so *now* that it did so *then*, but the reverse. Light and heat are the means, now, of forming and consolidating vegetable elements into woody fibre, because, at the eventful period to which we allude, it pleased the Creator, by the announcement of His will, that one of the progressive fundamental laws of nature should be—that light should be made his agent, in forming and completing those variegated and interesting objects, the phanogamous classes of the vegetable kingdom, which were then to be brought into existence.

With respect to the previously formed *cryptogamous* plants, whose reproductive organs are mere sporules, or analogous receptacles, possessing neither radicle nor plumule, and quite indifferent to polar energy, being such as were not compre-

* According to the tenor of the *second* Theorem and evidences.

hended in the terms, "herb bearing seed, and fruit-tree yielding fruit, whose seed is in itself upon the earth," we would make merely a few brief observations.

The earth, as we have seen, having been empowered, with the aid of the elements placed at its disposal, to produce the flowering, seeding classes of plants, we are warranted in surmising, that the same agent—the earth—was the means which the Creator, likewise, made use of to create the primeval cryptogamous kinds at or during "the beginning;" and, following up this assumption, we may conclude, that, in obedience to the more general and comprehensive laws of materialism, there would be a conformity in those which governed the production of those species; and, indeed, of every thing else throughout the wide domains of materialism; for we feel well persuaded of the important truth, *that it was the same great principle—the light—which conferred, alike, polarity on the earth and every other rotating spheroid, and polarity on every germinating body, even to "a grain of mustard seed!"* When the earth, by having rotation impressed upon it, was endowed with poles, it produced plants whose reproductive organs have radicle and plumule; and whose energies and vitalities propend in different ways, and with relation to polar directions; which, of course, pre-supposes the existence of the unseen fluid, which occasions this polar sensativeness of structure and method of proceeding on the part of the phanogamous plants. But, while the earth lay slumbering in the dark womb of nature, without poles or axis, but was itself the sporule of a world, it is but consistent to suppose that it could only confer on the reproductive bodies of other objects—we mean, on its then restricted vegetable kingdom—faculties which were akin to those which itself possessed; a conclusion fully borne out when we reflect, that the subtile imponderable fluid which occasions polarity had not then been called into existence; and hence, when we take into consideration the common origin, and unity of design in all the works of creation, we shall have no reason to expect, that the earth, in producing any of them by delegated power, could endow the reproductive organs of the primitive and restricted vegetation with faculties of a higher order, or which required, for their development, the influence

of a force to which it had not itself, before its rotation, been subjected, and which, in fact, did not exist. For this would be to presume a crude anomaly in the laws impressed on materialism which we nowhere find to be the case. And, therefore, we should, *a priori*, have expected to have found, what experimental botany, when applied to the extinct fossil vegetation, has revealed as actually existing, namely, that the fossil objects of the vegetable kingdom, which are considered to have belonged to that remote era and condition of the globe, when brought into comparison with recent equivalents, are found to belong to those orders whose reproductive organs are indifferent alike to polarity, or to the putting forth of vegetative energies in the opposite directions of *radicle* and *plumule;* but send forth their expansions from whichever side mere casualty brings into contact with the ground. And it is thus, when we view the whole works of creation as emanating from the same Divine and Omnipotent source, that we are best able to estimate their comprehensiveness, to perceive all their beauties, and be convinced of the thorough and harmonious consistency the one with the other.

"It must be obvious, on consideration," says the practical Author of Botany in the Library of Useful Knowledge, "that plants in which there exists neither stamens nor pistils, and in which there cannot take place any of those phenomena we have lately been examining when treating of phanogamous plants, must also be destitute of seeds, ... but if they have not reproductive organs, like those of plants of a higher organization, they are furnished with matter of another kind which answers the purpose equally well. This matter consists of what is called *sporules* or *spores*. . . . . .

"In the more perfect of the tribes of flowerless plants, there can be no doubt that spores act precisely like seeds in reproducing the species. In regard to those of ferns and mosses, no difference exists between seeds and spores, except as to the organ, organization, and mode of development of the latter. Instead of having their centre divided into plumule and radicle, to which one or two cotyledons are attached, they are mere homogenous masses of cellular substance, and instead of uniformly growing from two constant points of their surface, from one upwards and from the other downwards, they are capable of sprouting into root or stem indifferently from any point of

their surface; the nature of the parts which the spores produce depending, not upon pre-existing organization, but upon accidental circumstances. When they begin to grow, that portion of the surface which is exposed to light extends into a stem, and that which is turned to darkness and humidity becomes root.

"Mirbel found in his experiments upon marchantia, that it was possible, up to a particular period of growth, even to induce the parts that had developed to change their functions, the rudimentary stem taking on itself the office of a root, and the new born root becoming stem when their situation was inverted. . . . . .

"Yet," he very appropriately concludes, "we must not be led astray by specious theories and imaginary facts concerning bodies so far beyond the cognizance of our senses, as to place any faith in ideas of equivocal generation. But in the absence of demonstrative evidence to the contrary, let us believe the great Author of Nature to be consistent with himself in all his works; and to have taken care to enable the most humble *sea weed* to be multiplied by some means as certain and unchangeable as the most stately lord of the forest. We may rest assured, for all philosophy, all observation, and all reason prove it, that there is no such thing in nature as blind chance; but that all things have been carefully and wisely designed, with reference to the particular circumstances under which they exist."*

The remarkable persistency of the general law above alluded to, not only serves to corroborate the soundness of the position we have assumed from the first; but, likewise, to make manifest the wise arrangement, and the design of the creation—developed according to one great and comprehensive plan—which subjected the planets of the system, and the sporules of the cryptogamia alike to its power, and its all pervading influence. And it is, when we are enabled thus to elevate our minds somewhat above the trammels which usually confine them here, and with a bold yet faithful stretch of imagination, to conceive all the works—minute and great—of creation emanating from the same divine and omnipotent source, and consistent with and subject to the same great and comprehensive laws, that we are enabled to recognise more clearly the adap-

* Botany, Library Useful Knowledge, pp. 117—119.

tation of one towards the other, and the beautiful harmony of the whole; while the contemplation inspires us with tenfold more lively feelings of love and adoration towards our and their beneficent and common Creator.

In the prosecution of our subject, we have now to become acquainted with another peculiarity in the vegetable kingdom. In the *twelfth* Theorem, it is stated:—"*That the continents, and even the islands, are found to possess a flora of species peculiarly their own. That whilst a considerable number of plants are common to the northern regions of Asia, Europe, and America, where these continents almost unite, towards the south, where they widely diverge, the floras of these three great divisions of the globe differ very materially, even in the same parallels of latitude. And, that upon the principle of distinct floral foci of creation, the whole earth has been divided, by botanists, into a certain number of botanical districts, differing from each other almost entirely in their specific vegetation.*"

"It seems to be a natural consequence," observes Professor Henslow, with his usual perspicuity, "of our considering the geographical distribution of every species to have taken place by its gradual dispersion from one definite spot on the earth's surface, that some would be found only in one district, and others in another, provided these were separated by some great physical feature, such as a chain of mountains or a wide sea; and that two such districts, though they might lie under the same parallel of latitude, would contain few species common to both. Such districts are termed 'botanical regions.' These are spaces enclosing particular species, distributed through them in the stations adapted to their growth; but so encompassed by physical obstructions, that the great majority of species found within their limits are not to be met with elsewhere. . . . . . There are about fifty of these regions whose floras have been partially examined, and of which lists have been given. . . . . The centres of Africa, Asia, and other unexplored districts probably afford several more. Twelve of these regions enumerated belong to the northern hemisphere, between the pole and tropic of Cancer; twenty-six are intra-tropical; and seven are extra-tropical, in the southern hemisphere. The first are the largest, and approach each other the nearest; the second are less extended, and more frequently

separated by the ocean and deserts; the last are very unequal in extent, and above all, more dispersed, many of them being small islands in the midst of an immense ocean. . . . . . Many local circumstances produce remarkable modifications in the relative proportions between the species of different classes and orders, in regions under the same parallels of latitude. Thus, for instance, *cæteris paribus*, the cryptogamic tribes flourish most in moist regions. The places best adapted to the growth of ferns are the islands in tropical climates, in some of which, as in St. Helena, one-half the flora is composed of them. It is remarkable that in this respect, and as regards the existence of arborescent species in this order, the ancient flora of our coal fields appears to approximate very closely to that of islands situate in the midst of an extended ocean and in low latitudes. The same causes which appear favourable to the increase of cryptogamic species, seem also to produce a diminution in the proportions which dicotyledons bear to monocotyledons. Other relations of considerable interest have been pointed out between the species of different orders, occurring in different regions; but we cannot enter into the minutiæ of their details, our object being rather to present the reader with the principles on which such investigations depend, than to acquaint him with the partial results which have hitherto been deduced from them; several of which must doubtless be greatly modified hereafter, considering the little knowledge we at present possess of the floras of many parts of the world."*

"The gradual decrease of temperature," Mrs. Somerville says, "in the air and in the earth, from the equator to the poles, is clearly indicated by its influence on vegetation. In the valleys of the torrid zone, where the mean annual temperature is very high, and where there is abundance of moisture, nature adorns the soil with all the luxuriance of perpetual summer. . . . . . But the richness of vegetation gradually diminishes with the temperature; the splendour of the tropical forest is succeeded by the regions of the olive and vine; these again yield to the verdant meadows of more temperate climes; then follow the birch and the pine, which probably owe their existence in very high latitudes more to the warmth of the soil than to that of the air. But even these enduring

* Botany, in Cab. Cyc. pp. 304—309. We recommend that the whole passage should be perused; that given here is merely an abstract.—AUTHOR.

plants become dwarfish, stunted shrubs, till a verdant carpet of mosses and lichens, enamelled with flowers, exhibits the last signs of vegetable life during the short but fervent summers at the polar regions. Such is the effect of cold on the vegetable kingdom, that the number of species growing under the line, and in the northern latitudes of 45° and 68°, are in the proportion of the numbers 12, 4, and 1. . . . . . By far the greater part of the hundred-and-ten thousand known species of plants are indigenous in equinoctial America. Europe contains about half the number; Asia, with its islands, somewhat less than Europe; New Holland, with the islands in the Pacific, still less; and in Africa there are fewer vegetable productions than in any part of the globe of equal extent. . . . . . With regard to the vegetable kingdom, elevation is equivalent to latitude, as far as temperature is concerned. In ascending the mountains of the torrid zone, the richness of the tropical vegetation diminishes with the height; a succession of plants similar to, though not identical with, those found in latitudes of corresponding mean temperature takes place: the lofty forests by degrees lose their splendour, stunted shrubs succeed, till, at last, the progress of the lichen is checked by eternal snow. On the volcano of Teneriffe there are five successive zones, each producing a distinct race of plants. The first is the region of vines, the next that of laurels; these are followed by the districts of pines, of mountain broom, and of grass; the whole covering the declivity of the peak through an extent of 11,200 feet of perpendicular height. . . . . . It is not in this instance alone that similarity of climate obtains without identity of productions; throughout the whole globe a certain analogy both of structure and appearance is frequently discovered between plants under corresponding circumstances, which are yet specially different. It is even said that a distance of 25° of latitude occasions a total change, not only of vegetable productions, but of organized beings. Certain it is that each separate region, both of land and water, from the frozen shores of the polar circles, to the the burning regions of the torrid zone, possesses a flora of species peculiarly its own. The whole globe has been divided into botanical districts, differing almost entirely in their specific vegetable productions; the limits of which are most decided when they are separated by a wide expanse of ocean, mountain chains, sandy deserts, salt plains, or internal seas. A considerable number of plants are common to the northern regions of Asia, Europe, and America,

where the continents almost unite; but, in approaching the south, the floras of these three great divisions of the globe differ more and more even in the same parallels of latitude, which shows that temperature alone is not the cause of the almost complete diversity of species that everywhere prevails. . . . . . It appears from the investigations of M. de Humboldt, that between the tropics the monocotyledonous plants, such as grasses and palms, which have only one seed-lobe, are to the dicotyledonous tribe, which have two seed-lobes, like most of the European species, in the proportion of one to four; in the temperate zones they are as one to six; and in the arctic regions, where mosses and lichens, which form the lowest order of the vegetable creation, abound, the proportion is as one to two. The annual monocotyledonous and dicotyledonous plants in the temperate zones amount to one-sixth of the whole, omitting the cryptogamia; in the torrid zone they scarcely form one-twentieth, and in Lapland one-thirtieth part. In approaching the equator, the ligneous exceed the number of herbaceous plants; in America there are a hundred and twenty different species of forest trees, whereas in the same latitudes in Europe only thirty-four are to be found. . . . . . Various opinions have been formed on the original or primitive distribution of plants over the surface of the globe, but, since botanical geography became a regular science, the phenomena observed have led to the conclusion, that vegetable creation must have taken place in a number of distinctly different centres, each of which was the original seat of a certain number of peculiar species, which at first grew there and nowhere else. Heaths are exclusively confined to the Old World, and no indigenous rose tree has ever been found in the New; the whole southern hemisphere being destitute of that beautiful and fragrant plant. But this is still more confirmed by multitudes of particular plants having an entirely local and insulated existence, growing spontaneously in some particular spot, and in no other place; for example, the cedar of Lebanon, which grows indigenously on that mountain and in no other part of the world."*

We must next endeavour to discover, with greater speciality than even these quotations point out, whether any, and what proportion of the flora of these distinct centres or foci pertain

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* Connexion of the Sciences, pp. 278—283, necessarily very much abridged.

to the *Phanogamous* division—that is—the *Monocotyledonous* and *Dicotyledonous* classes of plants. With this view, the following evidence will be perused with advantage. Mr. Lyell, with reference to M. Humboldt's personal narrative, gives the following:—

"Every hemisphere," says this traveller, "produces plants of different species; and it is not by the diversity of climates that we can attempt to explain why equinoctial Africa has no laurinia; and the New World no heaths; or why the calceolariæ are found only in the southern hemisphere. . . . . . We can conceive," he adds, "that a small number of the families of plants; for instance, musaceæ and the palms, cannot belong to very cold regions, on account of their internal structure and the importance of certain organs; but we cannot explain why no one family of melastomas vegetates north of the parallel of thirty degrees; or why no rose-tree belongs to the southern hemisphere. Analogy of climates is often found in the two continents without identity of productions.

"In further illustration of the principle above alluded to, that difference of longitude, independently of any influence of temperature, is accompanied by a great and sometimes a complete diversity in the species of plants. De Candolle observes—'That out of 2,891 species of phanogamic plants described by Pursh, in the United States, there are only 385 which are found in northern or temperate Europe. MM.Humboldt and Bonpland, in all their travels through equinoctial America, found only twenty-four species, these being all cyperacea and graminea (monocotyledons) common to America and any part of the Old World.'"

"In the Canaries," continues Mr. Lyell, "out of 533 species of phanogamous plants, it is said that 310 are peculiar to these islands, and the rest identical with those of the African Continent."

And again—

"The entire change of opinion which the contemplation of these phenomena has brought about is worthy of remark. The first travellers were persuaded, that they should find, in distant regions, the plants of their native country; and they took pleasure in giving them the same names. It was some time before this illusion was dissipated; but so fully sensible did botanists at last become of the smallness of the number of phanogamous plants common to different continents, that the ancient floras fell into disrepute. All became

diffident of the pretended identifications, and we now find that every naturalist is inclined to examine each supposed exception with scrupulous severity."*

Professor Henslow says—

"So far as calculations have hitherto been made, the following general laws appear to be correct; and it is not likely they will be modified by any additional information which future researches may procure:—

"1. The proportion of cryptogamic to phanogamic species, increases as we recede from the equator.

"2. The proportion of dicotyledons to monocotyledons, increases as we approach the equator.

"3. The absolute number of species, and also the proportion of woody species to the herbaceous, increases as we approach the equator."†

By the results of this last enquiry we are now enabled so far to modify the conclusion come to in the *twelfth* Theorem, as to pronounce, *that of the distinct flora found, peculiar to the continents and islands of the world, a considerable proportion is* PHANOGAMOUS; and which will enable us, with perfect confidence, to draw any deduction from it that may be considered conclusive.

What, then, ought to result from the introduction of these truths amongst the others which have been formerly established? It has been proved, as far as our argument is concerned, that the different centres or foci of the vegetable kingdom are identified with or dependant upon there being detached continents and islands on the earth; that is, they are bound up or connected with the greater inequalities of its surface; while, of the plants forming these distinct floral foci, a considerable number pertain to the *monocotyledonous* and *dicotyledonous* classes, or the *phanogamous* division of the vegetable kingdom. But it has, likewise, and as clearly been shown, that these two perfect classes could not have existed previously to the formation of the light and of the atmosphere;

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* Principles of Geology, vol. ii. pp. 71—75.

† Botany, in Cab. Cyc. p. 308.

that they were called into being through the instrumentality of a supernatural suffusion of light, leading directly to the conclusion, that their formation took place *before* the light was placed, as it now is, in the centre of our system; and the inspired narrative having declared, that the former of these events took place on the *first*, and the latter on the *fourth* day of the Mosaic week, *we are, thereby, enabled*, by means of the phanogamous vegetable classes, *to determine the period*, WITHIN THREE DAYS, WHEN THE EARTH RECEIVED ITS PRESENT FORM.

This conclusion we consider so legitimate a deduction, from the well authenticated fact of the existence of distinct foci of creation of phanogamous flora—when brought to the test of our own assumptions, based alike on the announcements of scripture, and on the experience of scientific men—that no room seems left for the smallest doubt on the subject. Those continents and islands, which constitute the detached and distinct floral centres, bearing flowering, seeding plants, must have been formed, and have still retained the form given to them *at some period between the first and the fourth days of the Mosaic week.* And if from the latter we deduct the several increments of time which it pleased the Creator should be occupied in the formation of the atmosphere, in the separation of the land from the sea, and in the production of the phanogamous plants themselves, we shall be thrown back on the *first day of the Mosaic week, as that on which the present great outlines and inequalities of the earth's surface were indelibly impressed upon it.*

It may be remembered, that in a previous part of this work, we concluded, that the earth received its actual geographical outlines, in consequence of the first revolution which it performed around its axis, as an immediate effect of the formation of the primary light and its expansive influence, when it was divided from the darkness; and as the deductions from the existence of distinct floral foci point to the same period, we are thus furnished with another and a very interesting corroboration of the soundness of the former inference. The erratic boulders and blocks, dispersed by the first revolution of the earth around its axis, afford us, though occasional and

detached, yet widely spread evidences of the origin and permanency of these great inequalities of surface. But the trees, shrubs, and grasses found in distinct foci, furnish us with a more minutely and closely interwoven web of evidences, which, filling up the interstices and covering the whole terraine surface of the globe, do away with the last refuge for doubt or scepticism; while our own satisfaction in bringing forward this new series of proof, is greatly heightened by considering, that such favourite objects as are the flora in the great repository of nature, should have, by their presence, so effectually contributed to establish the point in question; and have afforded their humble but undeniable testimony to the truth of those announcements, which we veritably believe proceeded from their and our common Creator.

We have just said, that these combinations have reduced us to a period whose extent cannot exceed that of three days; on some one of which the earth must have received the more prominent inequalities of surface which it still retains; and resuming the subject, with the design of going more into detail, we shall now endeavour to determine *on which of those three days the change of form alluded to actually took place.*

Assuming the last evidences which have arisen from the phanogamous classes of the vegetable kingdom, we are by them enabled to conclude, that both the soil to which they are fixed, and the atmosphere in which they grew, were formed *before* the plants, comprising these, were called into existence; and in consequence to eliminate a portion of the ultimate time as being that occupied in the production of those essential elements, the soil and atmosphere, leaving us the remainder for the formation of the earth.

Now, every evidence, which has been brought to bear upon the argument, has tended to prove, that the formation of the atmosphere must have *succeeded* the establishment of the *inequalities* of the earth's surface; and did not precede them, because it is more reasonable to suppose, that the aerial ocean was formed *after* these elevations and deep depressions had been made, than that it should have existed while as yet the earth was a sphere; and, therefore, by deducting from the remaining time that which is stated to have been occupied by

the Creator in making and perfecting the atmosphere, and separating, through its instrumentality, the land from the waters, without which these plants could not have existed, *we are carried back to the first day of the Mosaic week, as that on which the earth received the greater inequalities of surface which it still preserves*—a conclusion which is in the strictest accordance with what has ever been set forth by this, the Dynamical Theory; and it is to be hoped, that concurring testimonies, drawn from so many separate sources and different branches of science, will carry such conviction to the mind, as shall remove every doubt, and impart that most inestimable of all blessings, perfect belief in the harmony which exists between the WORKS and the WORD of GOD.

We have thus, by His kindness, been enabled to bring our labours to a point where, according to the order of sequence, in that portion of scripture which relates to them, there appears to have taken place a manifest change in the manner of conducting the process of creation. Hitherto the light, the chief agent employed, had been maintained by the Omnipotent in such a state, as to be capable of being imparted in the manner and quantity most suitable for the completion of the works which he contemplated; and which were developed in succession. But from this period ever afterwards the light was destined to be so restricted, as to be given forth in fixed and regulated quantities; issuing, not directly by a special fiat of the Creator whenever it was to be imparted, but in regular and constant supplies from luminaries formed by His wondrous wisdom and power; and placed in the firmament of the heavens between himself and His creatures, to dispense the light and heat best suited to their wants and comfort.*

Amongst the numerous motives for wonder and admiration which this remarkable change, in the method of procedure, seems fitted to produce in the mind, perhaps not the least extraordinary is the announcement of its having taken place precisely on the conclusion of those parts of the creation *which may be considered as unendowed with volition:* a coincidence so remarkable between the *period* of this all-important change,

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* See the *second* Theorem.

and the *kind* of beings which were willed into existence thereafter, that, joined to the impression of there being a necessity for the modification in question, it fully convinces us; and we trust, that every one else who reflects on the subject of the divine origin of both conditions of the light, and also of the operations which were performed by its instrumentality in those different states, will feel equally well assured.

Hitherto whatever had been formed was either inert matter, aeriform masses, liquid fluids, or vegetable existences, without any of them possessing the power of volition or locomotion, properly so called. But before the beneficent Creator proceeded to embody those free-moving creatures which were to roam in the ocean, inhabit the land, or to fly in the air, there appears to have been some constraining reason, having its origin in the relation of their movements to the surrounding media, which demanded that the quantity of light should be equable and regulated; *and that it should henceforth issue* FROM *the same point* TO *which the principle of attraction propends.*

It is not our intention, at present, to lead our readers into the depths of an enquiry, having for its object an endeavour even to surmise in what that mysterious necessity consists. But a brief and comprehensive review of the leading features which characterize the operations of the three days which we have been engaged in contemplating, will not only go someway towards elucidating this new principle, but will, likewise, show how intimately connected are these works with the introduction of the light into the material universe, and the rotation of the earth around its axis: the main tenets, and fundamental doctrines of the Dynamical Theory.

The first day of the Mosaic week, as we have been informed, was dedicated to the formation of the light itself, that is, the ethereal fluid and its subsequent division from the darkness; while their immediate consequence, as concerns this world, was the rotation of our sphere on its axis, producing in turn those innumerable geological and geographical developments, which everywhere characterize the earth's surface.

A proper degree of attention bestowed upon what is said respecting the operations of the two succeeding days, will en-

able us to discover, in the most unequivocal manner, that light, the rotation of the earth, and the consequences arising therefrom, were mainly influential in effecting, under the direction of the Creator, the wonders of the second and third days. For, on looking narrowly into the details of the *second* day, it will be observed, that it was the principle of expansion, proceeding from the light, which insinuating itself among the waters and combining with their elements or associates, caused them to assume the elasticity and volume requisite to form the atmosphere; while it was to the centrifugal impetus, occasioned by the diurnal motion of the earth, that the elevation of the continents and the depression of the oceanic hollows are due; and which, in turn, threw the body of waters into a favourable condition for being united with the expansive principle of light, and for being in part transformed into the gaseous elements of the atmosphere.

Again, on the *third* day, it was this newly-formed aerial body which was chiefly instrumental in separating the water from its earthy, saline, and acidulous ingredients; and in raising it off the lands, whereby a separation between the two component parts of the *terraqueous* surface was effected, and each rendered the fitting habitation of the various kinds of plants and animals, with which they were respectively to be tenanted. While, towards the close of the same day, it was light; and the presence of the atmosphere with its watery vapour and gaseous associates and ingredients, which enabled the earth to obey the mandate of the Omnipotent, and to produce the herbs and trees with which its surface is now so beautifully variegated and adorned.

And thus we are made to perceive, in the most convincing manner, that all the stupendous transactions of these three primary days may be traced *to the introduction into the creation of indefinite quantities of the principle of expansion proceeding from light;** *and to the immediate consequences of its division from the darkness on the first day;* while it must appear a self-obvious truth, that these supplies could neither

* The expressions here used are designed merely as *indefinite*, in contradistinction to the *measured* supplies now received from the sun.

have been of the same nature, nor dispensed in the same quantities in which they are *now* received from the sun; and, therefore must have anteceded, as we are informed in scripture they did, its final fixation around the central orb of our system. The contemplation of which event, and the results proceeding from it, will form the subject of our next section.

Meanwhile, the general impression left upon the mind, by the perusal of what has been written, necessarily is, that the whole of these operations are linked together in the most intimate manner; and so far, apparently, under the necessity of a fixed order in the mode of their arrangement, as to require that the unfolding of the one part should precede the unfolding of the other, while itself depended upon the unfolding of one still more antecedent, like the unrolling of some vast plan admirably delineated by consummate wisdom and skill, where all the separate parts and detached groups are made to harmonize with each other, and to form one grand whole of the most perfect symmetry! of which the boldest and truest conception we can imagine, is, *that they constitute the material results of the decrees of God*:—the materializing of that which had been devised from all eternity, and whose execution required the INSTITUTION *of an* ORDER *of* CAUSES; every act recorded in the first chapter of Genesis establishing a primary material cause, productive of consequences whose invariable repetition have acquired for them the term of NATURAL EFFECTS. While the causes, themselves, thus emanating directly from the Omnipotent, compose NATURE'S CONSTITUTIONAL CODE, whose contravention cannot, under any circumstances, be attempted with impunity.

SECTION IX.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND COMPLETION OF THE WORK OF CREATION.

CHAPTER XXXVI.

Resumption of the promise given to prove, that during the first three days of the Mosaic week the Light was not concentrated around the Sun. Primitive state of the Light and supposed Centre. Analogical authority, deduced from astronomy, for assuming, that primarily the Light had a different nature from that which it now has. Evidence to this effect, and that it was precisely similar in kind, though differing in degree, with the force which occasioned the orbital motion of the spheres. Assumption that the sun, together with all the planets, were caused to rotate around their respective axis by means of the primary light, and its division from the darkness. Astronomical proof of the sun's rotation. Dynamical law to show, that equal but opposing forces produce equilibrium. Astronomical evidence that equal amounts of heat and light are received by the earth from the sun in passing over equal angles round it. These two bodies of evidence made to show, that the Light, as now constituted, could *not* have caused either the sun or the earth to rotate. The same conclusion deduced from the *direction* in which the light is now received from the solar centre.

In a previous part of this work we promised to prove, that wherever the light was, or whatever was its intimate nature during the first three days of the Mosaic week, *it was not situated—it had not its centre—in or around the sun as it has at present;* on the assumption that had it been so placed it could *not*, in accordance with laws then existing, have accomplished what it did perform, under supreme direction, during that period. We now purpose, if possible, to redeem the pledge then given, while we solicit every consideration in consequence of the difficulty of the undertaking; and the

abstract nature of the reasoning which, alone, can be employed.

In order to leave the unity of our future argument unaffected it may perhaps be as well, before entering upon it, to come to some definite understandiug as to the state in which the light is considered to have been, or the centre or centres from whence the light is supposed to have proceeded, previous to its concentration around the sun, and during the three days when it produced, under Divine direction, those stupendous effects which we have so lately been considering.

Assuming, therefore, as we have all along done, that it did *not* emanate, as now, from the centre of our system during the first three days of the Mosaic week, we may assign for it during that period any other condition of its existence which may be most consistent with what is made known to us by Revelation, and in accordance with natural phenomena.

In doing this we are neither so wholly beyond the limits of probability, nor so destitute of the means of reasoning as the startling nature of the subject appears, at first sight, to indicate. It is true, it is both abstruse and difficult; but even, with all, the differential method of argument may, with a little industry and dexterity, be made available.

We affirm, therefore, that the sun was *not*, during the first three days of the Mosaic week, the centre of the light, whose formation and division from the darkness caused the revolution of the spheres around their axes, and the other important consequences resulting therefrom; and this merely because, *if so situated, it could not*—agreeably to the laws previously established, and which consequently were not to be infringed upon—*have produced those effects.* While we remit the proofs for this assertion to the sequel of this chapter, we shall, meanwhile, endeavour to come to some satisfactory conclusion as to where it may have been. To effect this, in the absence of all *direct* philosophical testimony, for who could expect philosophical proof in such a case as this? we must have recourse to the words of Scripture themselves, which treat of a period prior to the investigations of man—they are, "God said, Let there be light, and there was light." In these there is no *locality* assigned for the light; the mere act of its for-

mation is recorded by the inspired historian, and when we consider whose command it was which called it forth, we shall have no doubt as to its almost ubiquity; and we therefore maintain, that in the absence of a direct assertion as to its removal around the sun, we are not only at liberty, but are even bound to infer, *that it was not removed,* but remained where it was formed; and the more so, as its concentration, three days thereafter around its present point, is subsequently announced by the same historian when he asserts that "God made luminaries and *set them* in the firmament of Heaven." We may therefore, conclude, *that the light remained during the first three days where it was formed at first.* But it may be asked, *where* was it formed? "where is the way that light dwelleth? And as for darkness, where is the place thereof?"* Of this we are not informed, yet, notwithstanding, even here, we may, by investigation, come to some satisfactory conclusion; for we know positively, that all the works of the Creator are conducted by consummate wisdom and knowledge, and that he possesses power over all things to will them into those conditions most suitable for producing effects corresponding to that wisdom and knowledge, whereby we become impressed with the conviction, through the evidence of our senses, of his possessing those attributes. These considerations authorize us to conclude, in the absence of any direct announcement to the contrary—and with our conviction that the attributes mentioned are eternal, and must have preceded the formation of the light—that *the locality of this subtile influence would be precisely where best adapted for producing the effects which were to flow from it.* Before we can deny this conclusion we must impugn the validity of the announcements of Scripture, and deny the known and confessed attributes of the Deity.

We shall presently, in accordance with what we have already so clearly stated with respect to the ubiquity of the primary light, endeavour to show *where* we consider the locality to have been, or, in other words, the nature of the movement impressed upon it; meanwhile, to convince our readers that we are taking no unwarrantable, or at least no

* Job xxxviii. 19.

unprecedented liberty with their credulity, in supposing a centre or centres of impulse which no longer exist; and, at the same time to exonerate ourselves from the charge of recurring unnecessarily to final causes, we have to plead the example of astronomers, a class of men dedicated to the cultivation of a science which, of all others, possesses the best founded pretensions to the character of *exact*. In testimony of this we shall primarily adduce the fact contained in the second clause of the first part of the *fifth* Theorem, namely, "*That the planets move in orbits cutting the ecliptic at different degrees of obliquity;*" and shall content ourselves with bringing forward the evidence of Prof. Whewell on that point; who, when treating of the stability of the solar system, makes use of the following expressions:—

"They (the planets) might have had any inclination to the ecliptic from no degrees to ninety degrees. Mercury, which deviates most widely, is inclined 7¾ degrees, Venus 3¼, Saturn 2¼, Jupiter 1½, and Mars 2. How comes it that their motions are thus contained within such a narrow strip of the sky?"*

In continuation we shall refer to the *fourth* Theorem; "*That the orbital revolutions of the* EARTH *and other planets around the sun, almost in the plane of its equator, and of the satellites around their primaries, are caused by the combination of the sun and the planets' mutual attraction, and an original projectile impulse. . . . . . And that the same laws maintain the comets in their more elliptical orbits, their eccentricity depending wholly on the direction and force of the original impulse which put them in motion.*" The evidences in support of this theorem will exercise considerable influence on our future reasoning, and we shall, therefore, give them somewhat fully, and perhaps add some remarks on them from other sources afterwards.

"The moon," observes Mrs. Somerville, "is retained in her orbit by a force, having the same origin, and regulated by the same law, with that which causes a stone to fall at the earth's surface. . . . .

"Newton ascertained that a body projected in space, will move

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* Bridgewater Treatise, pp. 165, 166.

in a conic section, if attracted by a force proceeding from a fixed point, with an intensity inversely as the square of the distance, but that any deviation from that law will cause it to move in a curve of a different nature. . . . . .

"Kepler found, by direct observation, that the planets describe elliptic paths round the sun. Later observations show that comets move also in conic sections. And Kepler, likewise, deduced, that the squares of the periodic times of the planets round the sun are proportional to the cubes of their mean distances from his centre. Hence the intensity of gravitation of all bodies towards the sun is the same at equal distances.

"If a sphere at rest in space receive an impulse passing through its centre of gravity, all its parts will move with an equal velocity in a straight line; but if the impulse does not pass through the centre of gravity, its particles, having equal velocities, will have a rotatory or revolving motion, at the same time that it is translated in space. These motions are independent of one another; so that a contrary impulse, passing through its centre of gravity, will impede its progress, without interfering with its rotation. . . . . . It is computed, that had the earth received its motion from a single impulse, that impulse must have passed through a point about twenty-five miles from its centre.

"Since the motions of rotation and translation of the planets are independent of each other, though probably communicated by the same impulse,* they form separate subjects of investigation."

And in conclusion from this instructive writer—

"A planet moves in its elliptical orbit with a velocity varying every instant, in consequence of two forces, one tending to the centre of the sun, and the other in the direction of a tangent to its orbit, arising from the primitive impulse given at the time when it was launched into space. . . . . .

"On account of the reciprocal action of matter, the stability of the system depends upon the intensity of the primitive momentum of the planets, and the ratio of their masses to that of the sun; for the nature of the conic sections in which the celestial bodies move,

* However unwilling we may be to differ from a lady, and one so accomplished as Mrs. Somerville, yet we must enter our caveat here, and record our dissent from this assumption. The scope of our whole argument is opposed to it.—AUTHOR.

depends upon the velocity with which they were first propelled in space. Had that velocity been such as to make the planets move in orbits of unstable equilibrium, their mutual attractions might have changed them into parabolas, or even hyperbolas, so that the earth and planets might, ages ago, have been sweeping far from our sun through the abyss of space. But as the orbits differ very little from circles, the momentum of the planets, when projected, must have been exactly sufficient to ensure the permanency and stability of the system. . . . . . The magnitude of the sun's mass is the principal cause of that stability. There is not in the physical world a more splendid example of the adaptation of means to the accomplishment of an end, than is exhibited in the nice adjustment of these forces, at once the cause of the variety and of the order of nature."*

By the Treatise on Mechanics, in the Cabinet Cyclopedia, we are informed, as a grand and comprehensive exemplification of the law of INERTIA,

"That we are not without direct experience to prove, that motions, when unresisted, will for ever continue. In the heavens we find an apparatus, which furnishes a sublime verification of the principle. There, removed from all casual obstructions and resistances, the vast bodies of the universe roll on in their appointed paths with unerring regularity, preserving without diminution all that motion which they received at their creation from the hand which launched them into space. This alone, unsupported by other reasons, would be sufficient to establish the quality of inertia; but viewed in connexion with the other circumstances previously mentioned, no doubt can remain that this is an universal law of nature."†

By the same discourse on Mechanics, after some clear, preliminary explanations on the nature "*of the motion of bodies on inclined planes and curves*," we are told—

"That the pressure described has been denominated *centrifugal force*, because it evinces a tendency of the moving body to *fly from* the centre of the curve in which it is moved. Its quantity depends conjointly on the velocity of the motion and the curvature of the path through which the body is moved. . . . . .

* Connexion of the Sciences, pp. 5—16.

† Mechanics, in Cab. Cyc. chapter iii. p. 30.

"The centrifugal pressure increases as the radius of curvature increases; but it also has a dependance on the velocity with which the moving body swings round the centre of the circle of curvature. This velocity is estimated, either by the actual space through which the body moves, or by the *angular velocity* of a line drawn from the centre of the circle to the moving body; that body carries one end of this line with it, while the other remains fixed at the centre. . . . .

"The same causes which produce pressure on a body restrained, will produce motion if the body be free. Accordingly, if a body be moved by any efficient cause in a curve, it will, by reason of the centrifugal force, *fly off*, and the moving force with which it will thus retreat from the centre round which it is whirled, will be the measure of the centrifugal force. . . . . .

"The consideration of centrifugal force proves, that if a body be observed to move in a curvilinear path, some efficient cause must exist which prevents it from flying off, and which compels it to revolve round the centre. If the body be connected with the centre by a thread, cord, or rod, then the effect of the centrifugal force is to give tension to the thread, cord, or rod. . . . . . But if a body be observed to move in a curve without any visible material connexion with its centre, as is the case with the motions of the planets round the sun, and the satellites round the planets, it is usual to assign the cause to the attraction of the body which occupies the centre; in the present instance the sun is that body, and it is customary to say, that the *attraction* of the sun, neutralizing the effects of the centrifugal force of the planets, *retains them* in their orbits. We have, elsewhere, animadverted on the inaccurate and unphilosophical style of this phraseology, in which terms are admitted which intimate not only an unknown cause, but assign its seat, and intimate something of its nature. All that we are entitled to declare in this case is, that a motion is continually impressed upon the planet; that this motion is directed towards the sun; that it counteracts the centrifugal force; but from whence this motion proceeds, whether it be a virtue resident in the sun, or a property of the medium or space in which both sun and planets are placed, or whatever other influence may be its proximate cause, we are altogether ignorant."*

* Mechanics, in Cab. Cyc. chapter viii. pp. 99—102. From the circumstance of Sir John F. Herschel having directly referred, as it will presently be seen, to this explanation of centrifugal force, without giving any further explanation of

"The reader," says Sir John Herschel, "has now been made acquainted with the chief phenomena of the motions of the earth in its orbit round the sun, and of the moon about the earth. We come next to speak of the physical cause which maintains and perpetuates these motions, and causes the massive bodies so revolving to deviate continually from the directions they would naturally seek to follow, in pursuance of the first law of motion (see Mechanics, in Cabinet Cyclopedia, chap. iii.), and bend their courses into curves concave to their centres. . . . . .

"Is it not reasonable to imagine," he asks, a little farther on, that the force of gravity *may* extend so far as 60 radii of the earth, or to the moon? and may not this be the power—for *some* power there *must* be—which deflects *her* at every instant from the tangent of her orbit, and retains her in the elliptic path which experience teaches us she actually pursues?

"If a stone be whirled round at the end of a string, it will stretch the string by a *centrifugal* force (see Mechanics in Cab. Cyc. chap. viii.) which, if the speed of rotation be sufficiently increased, will at length break the string, and let the stone escape. However strong the string, it may, by a sufficient rotatory velocity of the stone, be brought to the utmost tension it will bear without breaking; and if we know what weight it is capable of carrying, the velocity for this purpose is easily calculated. Suppose, now, a string to connect the earth's centre with a weight at its surface, whose strength should be just sufficient to sustain that weight suspended from it; let us, at the same time, for a moment, imagine gravity to have no existence, and that the weight is made to revolve with the *limiting velocity* which that string can hardly counteract; then will its tension be just equal to the weight of the revolving body; and any power which should continually urge the body towards the centre, with a force equal to its weight, would perform the office, and might supply the place of the string, if divided. Divide it, then, and let gravity act in its place, and the body will circulate as before; its tendency to the centre, or its *weight*, being just balanced by its centrifugal force. Knowing the radius of the earth, we can calculate the periodical time in which a body so balanced must circulate to keep it up; and this appears to be 1h. 23m. 22s."

This accomplished astronomer then shows, by a succinct but

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its nature, we have considered it indispensable to introduce these quotations at some length, and at this particular juncture.—AUTHOR.

lucid chain of reasoning, which we are sorry our limits do not permit us to transcribe, that the application of this rate, and its striking nonconformity with the observed orbital period of the moon, necessarily constrain astronomers to assume, that the force of gravitation decreases at a ratio directly proportioned to the square of the intermediate distance; and that thus corrected, the rate above obtained yields the precise duration of the moon's orbital path around the earth.

And, in continuation, after making it manifest that the same reasoning, when applied to the case of the earth's revolution around the sun, accounts also satisfactorily for it, he enters upon the point which more immediately concerns us, by observing—

"Now, the moment we come to numbers, an obvious incongruity strikes us. When we calculate, as above, from the known distance of the sun, and from the period in which the earth circulates about it, what must be the centrifugal force of the latter, by which the sun's attraction is balanced (and which, therefore, becomes an exact measure of the sun's attractive energy, as exerted on the earth), we find it to be immensely greater than would suffice to counteract the *earth's* attraction on an equal body at that distance, greater in the high proportion of 354,936 to 1. It is clear, then, that if the earth be retained in its orbit about the sun by *solar attraction*, conformable in its rate of diminution with the general law, the force must be no less than 354,936 times more intense than what the earth would be capable of exerting, *cæteris paribus*, at an equal distance.

"What, then, are we to understand from this result? Simply this—that the sun attracts as a collection of 354,936 earths occupying its place would do, or in other words, that the sun contains 354,936 times the mass or quantity of ponderable matter that the earth consists of."*

And in another of his popular works, Sir John Herschel, when eulogizing Newton's *Principia*, thus expresses himself—

"In this great work, Newton shows all the celestial motions known in his time to be consequences of the simple law, that every

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* Astronomy, Cab. Cyc. chapter vii.

particle of matter attracts every other particle in the universe with a force proportional to the product of their masses directly, and the square of their mutual distance inversely, and is, itself, attracted with an equal force. By this he explains how an attraction arises between the great spherical masses of which our system consists, regulated by a law precisely similar in its expression; how the elliptic motions of planets about the sun, and of satellites about their primaries, according to the exact rules, inductively arrived at by Kepler, result as necessary consequences from the same general law of force; and how the orbits of comets themselves are only particular cases of planetary movements."*

A later and more discursive writer on the same subject gives us the following interesting sketch of these memorable discoveries:—

"When Newton began his profound research," observes Prof. Nichol, "he adopted, as a fundamental maxim, the assertion, that the laws of the matter of the heavens are, in regard of motion, not different from those of the matter immediately around us. . . . . . Founding on this necessary maxim, Newton began his enterprise by reflecting on the cardinal truth established by Galileo, *that every body, on receiving an impulse or a disposition to move, would move onwards for ever in a straight line in the direction of the impelling force, provided it continued undisturbed by any other force.* Now, as the planets move not in *straight lines* but *in curves*, he saw that some SECOND *and yet unknown power* must be continually acting on these bodies, bending their naturally straight paths into specific curves; and thus the enquiry regarding the nature of this *second* force, as to its seat and sphere of action, its variation under varying circumstances, and its comparative power over the different planets, was, by highest distinction, the problem of future astronomy, which, also, might lead to profounder disclosures." . . . . .

And, a little farther on, he concludes in the following words, with which we shall also close the evidence for this part of our argument:—

"Now, it might have been conjectured from the first, that the sun's attractive power over the revolving body would not be con-

* Discourse on Natural Philosophy, in Cab. Cyc. pp. 272, 273.

stant for all different distances; and the cardinal fact referred to expressed to Newton's mind not only that the sun's attractive force does vary with that distance, but also the *law of its variation.* That law, technically expressed, is as follows:—the sun attracts or deflects each planet by a force which diminishes *as the square of the distance increases;* and it is because his power over each of these orbs varies during all the variations of its distance, according to this peculiar rate, that all are constrained to revolve in some one of that small family of curves to which the ellipse belongs. Now, therefore, concerning that SECOND power, whose attributes our countryman had resolved to explore; not only had he clearly discerned its seat, but the law of its variation so distinctly, that, wherever a planet might be in its orbit, the exact amount of the force deflecting it from its rectilinear path, could be determined with an accuracy the most minute."*

We confess, that when we entered upon these evidences, and considering with whom we were about to deal, we had no idea they would have been so diffuse and so inconclusive, but we have been drawn into them unavoidably by the indirect manner in which the CENTRIFUGAL FORCE—the origin and somewhat of the nature of which it was our design to have elucidated—is mentioned in the works to which we have occurred for that purpose. In them it seems to be either inferred, implied, or merely assumed, *as a force which must unavoidably exist,* in order to complete the laws which govern planetary motion. This is a very remarkable feature in the writings of astronomers; who, otherwise, are so justly celebrated for the depth and extent of their acquirements, for the keenness of their scientific acumen, and for the scrupulous exactness of all their manipulations.

It will have been observed, that where we sought for some insight into, or a knowledge of the primary projectile impulse, or, as Mrs. Somerville expresses it, "the primitive momentum of the planets," we have been met by definitions—of the most lucid description, no doubt—of the laws of CENTRIPETAL ATTRACTION; those of CENTRIFUGAL FORCE being merely so far explained as a reference to those given in mechanical writers

* Contemplations on the Solar System, pp. 55—59.

would admit of; while, strange to say, the writer referred to, in the very chapter to which allusion is made, disclaims all knowledge of the intimate nature of even the countervailing force, ATTRACTION, supposed to be the better known of the two, and more immediately under our own cognizance, as deduced from the attraction of bodies on the earth's surface.

But let what we have now said suffice for the present; it is not our intention to retard the general discourse, or to deviate from the straight line of our argument, by the further disquisition of a subject, which others, of well known acquirements, have considered proper, as by common consent, to treat at such a respectful distance. Besides, we have every reliance on those in whose hands it must eventually be left for decision; and are persuaded, that if we have correctly attributed the "primitive momentum of the planets" to a force precisely similar in kind, though exercised at a period very widely apart from that which, ages afterwards, caused the slumbering spheres to revolve around their axes, and to produce, what *our earth* at least has ever since displayed, those undeniable evidences of protorotation, written in mineral characters of indelible duration and magnitude; then, they will confirm our opinion, and add to it the whole weight of their authority. Whereas, if we should be in error, they will correct this with the candour, urbanity, and proper feeling which characterize all their writings and all their doings.

We court investigation, because we seek the establishment of the TRUTH; and in no branch of science is investigation more likely to lead to correct and perdurable results, than in that of astronomy; therefore, we leave the decision to the followers of that sublime study. But ere we close, and while we commend this subject to their careful attention, we would take occasion to observe, that as it has been clearly demonstrated, that the Creator was pleased to put forth, at very divergent periods of the earth's geognostic history, distinct acts of creative power, whereby life was conferred on several successive races of animated beings; in each of which the *living principle* was no doubt entirely similar, although it gave impulse to diverse movements of differently organized beings; we have less, indeed we have no motive at all, to withhold our

assent to the conviction, if such should eventually be found necessary for the complete establishment of the truth, that it pleased him, in whom the fulness of all wisdom dwells, likewise to put forth, when the progressive stage of the work of creation required it, successive exertions of *impelling power.*

Wherefore should we hesitate to admit the undeniable conclusion? Is the conferring of life on a race of animated forms not as stupendous, though to us as mysterious an act of creative energy, as is the wheeling in space of a system of worlds of inert matter? Who can account for the one or for the other, except by declaring that each is alike the result of a fiat of the Omnipotent!

But while we reason thus, and are thus willing to refer the question of the *primary projectile impulse* to the unbiassed decision of astronomers, there are others who impugn the present system of belief with greater boldness. Presuming our readers may wish to be made aware of what has been said on the subject, we have selected the following, as bearing more directly on the point, and offer it accordingly to them:—

"The existence," Mr. Hutchinson observes, "of a projectile velocity or centrifugal force, calculated, with the aid of the force of gravity, to perpetuate the movements of planetary bodies in elliptical orbits, is a point that admits of no doubt. Till recently, however, nothing deserving to be called a theory, or hypothesis, purporting an explanation of the origin or cause of this force or velocity existed. Unlike the centripetal tendency, which was proven to result from an attractive influence subsisting between, and permanently inherent in, all ponderable materials, its origin or existence was never ascribed to any inherent property of matter, nor to any material cause. It was supposed to be an impulse or projectile velocity, originally communicated to planetary bodies by divine will and command. And as these bodies were conceived to revolve in their orbits through space, in which nothing material existed to obstruct their motion, such original impulse, when aided by a constant centripetal force, was calculated, without any renewal, or subsequent repetition, not only to prevent their mutual attraction producing any permanent approximation, but for ever to perpetuate the existing planetary movements.

The preceding explanation of the cause of centrifugal velocity is

liable to insurmountable objections. It is a mere assumption, resting on no evidence whatever, and supported by nothing analogous in nature. In fact, it seems to have been adopted for want of any other explanation, solely on the ground of convenience, in consequence of the power of gravity requiring the assistance of such a force, in order to account for the revolution of planetary bodies in elliptical orbits, agreeably to the relation, discovered by Kepler, between their periodic times and their mean distances from the sun. . . . . . Surely it need be hardly remarked, that such arbitrary diversity in the mode of generating planetary motion, is incompatible with the simplicity and unity visible in all the other designs of nature, and a hypothetical explanation of the cause of centrifugal velocity, which requires such variety, and yet such precision, in adjusting the amount and direction of impulse, without any other evidence than convenience and arbitrary supposition to support it, is totally inadmissible. . . . . .

" From the preceding observations it is obvious, that to suppose the original impulse is the cause of centrifugal force, is a mere assumption, resting on no evidence whatever; and instead of being supported, is actually contradicted by every thing analogous in nature. Besides, when it is admitted that the centripetal force originates not in impulse, but in the mutual attraction of matter; to disbelieve that nature employs impulse in generating centrifugal force, is no more sacrilege, than it was in the time of Torricelli, to call in question the doctrine, then universally received, of nature abhorring a vacuum, advanced in order to account for the water following a piston in a water pump."*

The perusal of those quotations should, we conceive, be sufficient to convince even the most scrupulous, that in a science such as astronomy, every result of which is the fruit of the most rigorous mathematical demonstration, its professors considered themselves warranted in having recourse to the doctrine of an "original projectile impulse, whose cause has ceased to operate;" the force and direction of which, differing for each planet and comet, can only be estimated relatively, or by the amount of the gravitation to which it is an equipoise; and whose estimated *direction*, even for that of the earth, appears to have been mistaken, although the amount of the impulse

* Hutchinson's Essay on Unexplained Phenomena, Glasgow, pp. 8—12.

be correct; while it is clearly admitted that the motion in space is quite independent of rotatory motion. Such being the case, we see no reason why we should be denied a similar privilege of supposing that the rotatory impulse produced by the formation of the light and its division from the darkness, originated from such a condition of the light as should be most conducive for impressing on the planets of our system those various degrees of obliquity of axis to the planes of their respective orbits, which astronomy announces they actually possess; when no one ever thinks of denying to the professors of that science the kindred assumption which they have embodied in their calculations, to account for the various rates of velocity of the planets and comets in their respective orbits, and the degrees of obliquity with which those orbits cut the plane of the ecliptic; while we again remind our readers that, in a previous section of this theory, we have expressed our opinion very clearly as to the almost ubiquity of the primary light—or that of the first three days—which we consider to have been the universal ethereal fluid; the impulse of motion communicated to it, when it was divided from the darkness, being that which we are now more especially treating of.

It is precisely with a view to our assuming the privilege alluded to, that we have entered into this preliminary discussion, and have given the quotations which have been perused; for, by the first part of the *fifth* Theorem, it will be seen, "*That the* EARTH *and other planets have their axes inclined at various degrees of obliquity to the planes of their respective orbits.*" The authorities which support this well-known astronomical truth may be consulted if desired, while we proceed to apply to it one of the facts elicited during the course of those investigations, namely, that the introduction of the light into the material universe and its subsequent division from the darkness, were the immediate causes of the spheres revolving around their axes; from which it follows as a direct consequence—similar to that of the assumed primary projectile impulse—*that its centre or centres, or more properly the impulses communicated, were precisely those whereby—according to the nature of the light then introduced—these different degrees of obliquity of axes with respect to the planes of their*

orbits could have been given by its means to the planets of our system.

This conclusion receives confirmation from the assumption, that the various degrees of obliquity, in the orbital motions of the planets, with respect to the plane of the ecliptic, proceeded from precisely the same principle and originated from causes of a similar *kind* with those which occasioned the differing degrees of obliquity of their axes to the planes of these orbits, the only dissimilarity being *the extent of the revolution performed*; for there must be considered an axis round which the revolution is described as really in the one case as in the other, although the points of their imaginary existence in space differ so far, that the former is considered to be in the centre of gravity of its periodical path, and, consequently, exterior to the mass of the planet, while the other is considered to pass through the centre of the revolving body itself. Still we maintain, that they each spring from causes, which, although put into activity at widely divergent periods, are precisely similar in *kind.*

Having removed this preliminary difficulty by thus showing, that we may justly, and without any unprecedented liberty, consider those centres of impulse which caused the rotation of the spheres to have been situated either in a point or many points where they no longer exist; in a manner similar to that which has been adopted by astronomers with regard to the "primary projectile impulse," which caused these bodies to revolve in space, whose operation is now supposed to have ceased; we shall continue the main scope of the argument designed to form the subject of this section; and commence by expressing our conviction, that we have, in a former part of this treatise, proved beyond the possibility of a doubt, *that the formation of the light and its division from the darkness, caused the earth to revolve around its axis.* Indeed, we feel assured that so long as there exists a single peak of granite perforating the strata, and pointing its scarped and rugged apex to the clouds, this truth may be considered irrefragable, and capable of supporting any superstructural chain of reasoning which may be raised upon it; and we trust the same degree of conviction has been impressed upon the minds of others,

as it will form a fundamental doctrine in all our subsequent reasoning. On this truth, which we have been at much pains to bring out in the clearest possible manner, and which is considered *to be perfectly independent of the precise locality of the centre of the light during the first three days of the Mosaic week*, we rely as on a citadel, to which we may retreat in case of being driven in from any of the more advanced outposts, not quite so capable of being rendered impregnable by investigation or by tangible proof. On the geological evidences we stand secure; if beaten back to them we need retreat no further, but quietly and calmly demand of our opponents to disprove our position on the junction of the primary with the secondary rocks; for sooner shall they be dissevered from each other, than the Dynamical Theory be disunited from the explanation which it affords, of the cause of their existence in the relative position which they now occupy. As long as this theory stands it supports the assumption of the non-rotation of the earth during the whole period required to produce these geological manifestations. And just as Gravitation, ascertained on the earth's surface, where it is within the reach of actual computation, is made the standard measure to determine the full power of that all-pervading force, whose comprehensive grasp assists to controul the material universe; so, we maintain, should the power which was put forth to tear up and dislocate the earth's mineral crust, when the globe was first made to rotate around its axis, be employed as a guage to determine, much more approximatively than we know at present, the mighty energy of that projectile force which was made use of, by the Creator, at the beginning, to overcome the entire inertia of the spheres themselves, when they were translated in space, and delivered up, for ever afterwards, to the unerring guidance of these justly equipoised but divellent forces, which together govern their orbital paths.

But the earth, though not impressed with diurnal motion during that period, must have revolved around the *un*illumined sun; and if it revolved around the sun, *the sun must have contained the precise amount of matter which it still possesses;* for any addition of *ponderable matter* made to the great central orb, when it became illuminated, would have destroyed the

equilibrium, which the earth and other planets around it, and all around the general centre of gravity, demand, in order to fulfil the conditions of their permanency.

This conclusion, unless indeed it can be proved, that the common centre of gravity of the solar system was changed on the sun's becoming illuminated, it is presumed is correct; and, therefore, to those who do not admit it, the arduous undertaking devolves, of proving upon equally responsible and solid bases, that the common centre of gravity of our system underwent a change on the fourth day of the Mosaic week. Will any one undertake to do this?

Assuming it to be established, that the earth did *not* rotate previous to the formation of the light and its division from the darkness; and that it did commence its rotatory motion in consequence of those events taking place, we consider ourselves authorised to carry out the same principle to all the other spheres of our system; and to conclude, with respect to them, *that neither did they rotate previous to the formation of the light;* consequently that all those which have been discovered to possess that motion, must, like the earth, have acquired it on the formation of the light and its division from the darkness. And it is presumed, that unless the other spheres of our system be differently constituted from our own, and governed by distinct laws (which we know is not the case), this assumption must be admitted, and be considered worth what it may amount to.

Now, the next point to be established is the rotatory motion of the sun. This we are at once enabled to do by referring to the second part of the *fifth* Theorem, which states, "*That the sun, and such of the planets as afford sufficient data for astronomical calculations, are known to have rotatory motion. That of the sun,*" *according to Delambre,* "*being completed in days 25.01154, which, although somewhat different from the estimate of others, yet all astronomers agree in that it does revolve around its axis.*"

The following important evidences prove the truth of this assertion:—

"The oblate form of several of the planets," observes Mrs. Somerville, "indicates rotatory motion. This has been confirmed in

most cases by tracing spots on their surface, by which their poles and times of rotation have been determined.

"The rotation of Mercury is unknown, on account of its proximity to the sun; and that of the new planets has not yet been ascertained. The sun revolves in twenty-five days and ten hours about an axis which is directed towards a point halfway between the polar star and Lyra, the plane of rotation being inclined by 7° 30′, or a little more than seven degrees to the plane of the ecliptic; it may, therefore, be concluded that the sun's mass is a spheroid flattened at the poles. From the rotation of the sun, there is every reason to believe that it has a progressive motion in space, although the direction to which it tends is unknown. . . . . .

"The sun and all its attendants rotate from west to east, on axes that remain nearly parallel to themselves in every point of their orbit, and with angular velocities that are sensibly uniform, ... that is, with an equable motion which is never either faster or slower."*

"It is hardly possible," says Sir John Herschel, when treating of the sun, "to avoid associating our conceptions of an object of definite globular figure, and of such enormous dimensions, with some corresponding attribute of massiveness and material solidity. That the sun is not a mere phantom, but a body having its own peculiar structure and economy our telescopes distinctly inform us. They show us dark spots on its surface, which slowly change their places and forms, and by attending to whose situations, at different times, astronomers have ascertained that the sun revolves about an axis, inclined at a constant angle of 82° 40′ to the plane of the ecliptic, performing one rotation in a period of 25 days, and in the same direction with the diurnal rotation of the earth, that is from west to east. Here, then, we have an analogy with our own globe; the slower and more majestic movement only corresponding with the greater dimensions of the machinery, and impressing us with the prevalence of similar mechanical laws, and of, at least, such a community of nature as the existence of inertia and obedience to force may agree."†

These perspicuous and convincing quotations, from authorities so well calculated to give them paramount importance,

* Connexion of the Sciences, pp. 75, 438.

† Astronomy, in Cab. Cyc. chapter v. p. 184, American edition.

might suffice to establish the several facts of the sun's rotation, and of its similarity of direction and assumed community of origin with the diurnal rotation of the earth; but we cannot refrain from adding another, while we are assured, from the agreeable language in which it is couched, that there is no probability of its being looked upon by our readers as a superfluity in the evidence adduced:—

"And now," says Professor Nichol, "that, with Copernicus, we have surveyed the exterior of the edifice we undertook to contemplate, and by the aid of Newton have unlocked its doors, let us venture within that august temple, and while we reverently walk through its halls, let us study the CONDITIONS COMMON TO ALL THE PLANETS. As before, *there* are they revolving around the sun in stated courses, each having a part in the living mechanism, of which gravity is the immediate sustaining power. But certain general facts, or laws, instantly strike the eye, not recognized by Copernicus as wonderful, and certainly not explained by gravity, considered merely as a *sustaining* power. Why, for instance, do these bodies all move nearly in circles, *i. e.*, in ellipses of the most trifling elongation? Gravity would sustain them, although moving in any ellipse. Why do they revolve all in the same direction, viz., from east to west? The direction of their motion is of no consequence to gravity. Why do the satellites of the primary planets partake uniformly of the same law? Why does every orb, planet or satellite, rotate on its axis in the very direction of its orbital revolution, which also is the direction of the rotation of the sun? Significance, and that a profound one, must rest within a concurrence so extraordinary; and guided by the genius of the most remarkable geometrician of the age, as well as by the boldness of its most original observer, I have elsewhere explained and traced it to the mode of our system's origin. . . . . .

And somewhat farther on, when closing in from these more general remarks, and treating of the CONSTITUTION OF THE SUN, he goes on to observe:—

"With much hesitation I approach this stupendous subject. Not only is the SUN the grandest body of our system, and the chief seat of the permanent energies that sustain it; but his surface, and in all likelihood his mass, is the scene of actions, compared with

which, the intensest displays of power known hitherto in any other globe shrink into utter insignificance.

"The phenomena that have led to some knowledge of the constitution of this vast orb, are those curious spots that appear and disappear so frequently on his surface, and which, by their regular progressive motion across his disc, revealed to their first discoverer, Gallileo, the remarkable fact, that the SUN rotates on his axis like the planets, carrying the spots along with him. The light, however, which they cast on the nature of the substance of this orb, was not recognized until the times of DR. ALEXANDER WILSON and SIR WILLIAM HERSCHEL."*

In continuation, we shall take it for granted, that all agree with respect to the rudimentary truth stated in the *second* Theorem: "*That the external light and heat received by the earth comes from the sun.*" Although, from its being irrelevant to our present purpose, we shall not stop to enquire whether it emanates from the body of that luminary, or, as now more generally believed, from a luminiferous atmosphere which surrounds it. These points will undergo special investigation in their proper places; meanwhile, all we wish to be conceded is, what cannot well be denied—*That the external light and heat received by the earth comes from the sun;* and, that it is received by us on whatever side we may happen to be of that central point of our system.†

It is not our intention, at present, to attach much importance to the argument which might be adduced, were any one hardy enough to undertake it, by supposing that the light which either resides in, or surrounds the sun, could ever have caused the solid nucleus of that luminary to revolve; because, if the light, by its expansive or repulsive power, that is, *by its tendency to proceed from the centre to the circumference,* be that which caused the bodies of the system to revolve, it would be absurd to suppose, that whatever resides *in* that centre could thereby have had rotatory motion communicated to it

* Contemplations on the Solar System, pp. 101, 102, 169, 170.

† See Meteorology, by Dr. Thomson, Introduction, pp. xix.—xxi. for a concise but clear elucidation of this fact.

so long as the light remained in the state it is in at present. We shall, therefore, proceed to a more certain line of proof. To do this, we must commence by being made acquainted with certain axioms in mechanics, in order that they may exercise their due influence over the truths which have already been established. First, then, let us have recourse to what is stated in the *seventy-ninth* Theorem:—"*That the power of a force to produce rotation is accurately estimated, not by the force alone, but by multiplying the distance of the direction of the force from the axis (called the leverage) by the force itself, the product of which is an important datum in mechanics, and is called the moment of the force around the axis. And, that if the moment or sum of the moments of the forces which tend to turn a body in one direction be equal to the moment or sum of the moments of forces which tend to turn it in the opposite direction, they will mutually neutralize each other and produce equilibrium.*"

Although this theorem be so essential to the development of our future reasoning, nevertheless, as the principles on which it is founded are undoubted, we shall require only to submit the data from which it has been constructed.

" The power of a force," it is stated in the Treatise on Mechanics in Cabinet Cyclopedia, " to produce motion is, therefore, accurately estimated, not by the force alone, but by the product found by multiplying the force by the distance of its direction from the axis. It is frequently necessary in mechanical science to refer to this power of a force; and, accordingly, the product just mentioned has received a particular denomination. It is called the *moment* of the force round the axis.

" The distance of the direction of a force from the axis is sometimes called the *leverage* of the force. The *moment* of a force is, therefore, found by multiplying the force by its leverage, and the energy of a given force to turn a body round its axis is proportional to the leverage of that force.

" From all that has been observed it may easily be inferred, that if several forces affect a body moveable on its axis, having tendencies to move it in different directions, they will mutually neutralize each other and produce equilibrium; if the sum of the *moments* of

those forces which tend to turn the body in one direction be equal to the sum of the *moments* of those which tend to turn it in the opposite direction, these forces will produce equilibrium."*

As it may be interesting, and cannot fail to be instructive to our readers, to be made aware of the effects which would be produced by "any variation in the mean temperature" of revolving bodies, even on one of such stable equilibrium as the earth we tread on, we give the following from the pen of Mrs. Somerville, to which we have been already so deeply indebted for information on kindred subjects:—

"But although these circumstances," she observes—when treating on the equality of the length of the day, and alluding to the ineffectual action on the diurnal rotation of rivers, trade winds, sun and moon, and of the eruption of volcanoes—"be insufficient, a variation in the mean temperature would certainly occasion a corresponding change in the velocity of rotation. In the science of dynamics, it is a principle in the system of bodies, or of particles revolving about a fixed centre, that the momentum, or sum of the products of the mass of each into its angular velocity and distance from the centre, is a constant quantity, if the system be not deranged by a foreign cause. Now, since the number of the particles in the system is the same, whatever its temperature may be, when their distances from the centre are diminished, their angular velocity must be increased, in order that the preceding quantity may still remain constant. It follows, then, that as the primitive momentum of rotation with which the earth was projected into space must necessarily remain the same, the smallest decrease in heat, by contracting the terrestrial spheroid, would accelerate its rotation, and consequently diminish the length of the day."†

Now, it must be obvious to every one, after perusing what we have just stated, that as "the external light and heat which we receive comes from the sun," and is equally imparted to us, whatever be the position we occupy in space with relation to that luminary, those rays must be *disseminated from it in all directions* whether they emanate from the body itself, or from a luminiferous atmosphere which surrounds it. But then we have just learnt "that equal forces acting in opposite di-

* Cab. Cyc. vol. v. pp. 135, 136. † Connexion of the Sciences, p. 82.

rections, with a tendency to cause rotation, so far from producing that motion, neutralize each other's influence, and produce equilibrium." And, as in the case of the sun, without entering on the question of the influence exercised by rays of light on the body whence they emanate, the same light proceeds from its equatorial region in every direction, we are authorised to consider these rays to be equal forces acting in all these directions; and applying the mechanical law above cited to this assumption, to draw the undeniable conclusion, *that the light as it is* NOW *constituted cannot, and consequently, never could have caused the solid body of the sun to revolve around its axis.* But, on the other hand, having been made aware, that the introduction of the primary material light into the universe occasioned the rotation of all bodies of our system around their respective axes, in which motion the central orb participates, the application of this truth to the conclusion we came to above, obliges us to consider, that although it was the light which caused the solid nucleus of the sun to rotate around its axis, *it could not have been the light as now situated or as now constituted.*

In fact, we consider the light of the first three days of the Mosaic week, that is, the primary light, to have been entirely different in its effects from that which was afterwards received from the sun. We look upon it, that these bore a somewhat similar relation to each other, to that which now subsists between the invisible electro-magnetic streams, capable of being made, in the hands of a skilful operator, to produce such wonders in decomposition and composition, and the brilliant radiance which bursts forth from the same currents, when the wires by which they are conducted are charcoal tipped, and made to collapse upon each other. They now illumine and dazzle by their visible splendour; they powerfully affect the eye, but they no longer produce, hiddenly, those almost miraculous changes on other bodies which they did before, when passing along silently and unseen by means of their conductors. And so with the primary light, during the first three days of its existence, ere yet there was an atmosphere, its conductor, and before the sea and the land were separated from each other, it was wholly invisible, and wonder working.

And all this was in perfect accordance with eternal wisdom, for we firmly believe, that up to that period there was not a material eye, within the whole scope of the universe, which could either have been benefitted by, or have beheld it.

This forms the first of a continued series of proofs which we intend to bring forward in order to demonstrate, that the primary light did not reside in or around the sun during the first three days of the Mosaic week; but that on the fourth day, when God saw fit, he set the light in the firmament of heaven to give light upon the earth.

The next proof to be adduced is somewhat similar to the preceding, namely—that had the light, from the first, been situated in its present centre, it could not have caused the *earth* to revolve around its axis. To substantiate this, let us consider it to be established, that our planet has rotatory motion; that it was impressed upon it by the expansive principle of the primary light; and that the sun's rays, proceeding in straight lines, strike the earth perpendicular to its surface, and consequently to its axis; and, then, let us become acquainted with what is contained in part of the *eightieth* Theorem—"*That if the force applied to a body be directed upon the axis, and at right angles to it, no rotatory motion will be produced.*" And again, "*If a sphere at rest in space receive an impulse passing through its centre of gravity, all its parts will move with an equal velocity in a* STRAIGHT LINE."

Combining these truths with what has been admitted above, the following self-obvious conclusion must be the result:—

That as the rays of sun-light (supposed, for a moment, to have been the impelling power) affect the earth in lines perpendicular to its centre of gravity, they could not, according to the mechanical axiom just cited, have caused the earth to revolve around its axis, *so long as they impinged upon it in that direction.* But as it has been admitted, that the earth does revolve, and that the introduction of the primary light into our system, and its division from the darkness, were the immediate secondary causes thereof, we are therefore necessitated, as in the preceding case, to look to some other relative position of the primary light with respect to the earth, and *some other state of it* as the cause of the rotation of this latter

body. *It was not the light as at present constituted, but it was the light; therefore it must have been the light from some other centre, and consequently in some other condition.*

Another corroborating proof can be drawn from nearly the same source; we allude to what is termed *the obliquity of the ecliptic;* the plane of the latter, or apparent path of the sun, being at present intersected by that of the *equator* at an angle of 23° 28′. Now, it has been considered by astronomers, that the longer axis of the elliptic orbit of the earth around the sun, coincided with the autumnal equinox about the period of the formation of the light; and it being admitted, that the light proceeds in straight lines from its centre, had it then flowed from the sun, it must have proceeded in lines parallel to the plane of the ecliptic; and, consequently, would have come into contact with the earth in such a direction as would have caused it (if it could have produced rotation at all under such circumstances) to have revolved with its axis perpendicular to that plane, or to the *ecliptic*, and not as it actually does, in lines perpendicular to the plane of the *equator*, which at present is 23° 28′, distant from the other, and formerly was somewhat more oblique; because this would be to admit the absurd conclusion, that the light could have acted in planes where it did not exist; or, what is the same thing, out of the plane where it was supposed to have been, if we imagine it to have been centered at that time around the sun. But as we have admitted, upon sufficient proof, that the primary light was actually the propelling power, whilst astronomy announces that the obliquity of the plane of the equator to that of the ecliptic, at the period we allude to, was nearly 24°, we are compelled, as in the preceding cases, to look to some other relative positions of the light with respect to the earth, and also to some other state of it for the explanation of the phenomenon in question; while the elaborate proofs and investigations we have gone through, domonstrate to a certainty, *that as far as regards the* DIRECTION OF THE IMPELLING POWER, *the primary light which caused the earth to revolve, did not come from the solar centre of our system.*

SECTION IX.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XXXVII.

Continuation of the argument commenced in the foregoing chapter. The non-concentration of the Light, during the first three days of the Mosaic week, deduced from the measured quantity of light and heat received at present, from the sun. Astronomical evidences. Confirmatory conclusion come to from these facts. The same deduction drawn from the circumstance, that the act of illuminating the Sun caused it to become the teller of the Earth's signs, seasons, days, and years. Contemplation of the magnitude of the achievement whereby the expansive principle was permanently fixed in the centre of our system. Corroborative conclusion from the peculiar direction in which the primary light acted, in order to occasion the rotation of the Earth; and presumptive evidence of its being akin to electro-magnetism.

Having been thus made aware, by arguments deduced in the preceding chapter, from the *direction* in which the light now flows to the earth, that it could not have caused it to rotate had it, when first formed, been concentrated around the sun; we intend in the present division, to pursue a distinct line of evidence in favour of the same argument; and to draw all our evidences from the *quantity* of light at present imparted daily by the sun to the earth. With this design we require to be made acquainted with the truths contained in the *second* Theorem before we can estimate their influence on what has been said, or on what we may have to advance. The proposition alluded to states, "*That the earth is a non-luminous body, receiving its external light and heat from the sun. And that the heat received is a fixed quantity, subject to the following*

invariable law, namely, 'that the momentary supply varies in the exact proportion of the angular velocity, i. e., of the momentary increase of longitude;' from which it follows, that equal amounts of heat are received from the sun in passing over equal angles round it, in whatever part of the ellipse these angles may be situated." The latter clause of this theorem, which is rather abstruse in itself, will exercise so important an influence over our reasoning in this particular line of proof, that we consider it essential to open it up somewhat more to our general readers.

Mrs. Somerville explains this astronomical law in the fol- perspicuous manner:—

"A planet moves in its elliptical orbit with a velocity varying every instant, in consequence of two forces, one tending to the centre of the sun, and the other in the direction of a tangent to its orbit, arising from the primitive impulse, given at the time when it was launched into space. Should the force in the tangent cease, the planet would fall to the sun by its gravity. Were the sun not to attract it, the planet would fly off in the tangent. Thus, when the planet is at the point of its orbit farthest from the sun, his action overcomes the planet's velocity, and brings it towards him with such an accelerated motion, that, at last, it overcomes the sun's attraction, and shooting past him, gradually decreases in velocity until it arrives at the most distant point, where the sun's attraction again prevails. In this motion the *radii vectores*, or imaginary lines joining the centres of the sun and the planets, pass over equal areas or spaces in equal times. . . . . .

And a little further on, when rebutting the erroneous ascription of the cause of decrease of temperature of the northern hemisphere, which is made apparent by the comparative size of its fossil flora, she thus expresses herself—

"This change of temperature has been erroneously ascribed to an excess in the duration of spring and summer in the northern hemisphere, in consequence of the eccentricity of the solar ellipse. The length of the seasons varies with the position of the perihelion of the earth's orbit, for two reasons. On account of the eccentricity, small as it is, any line passing through the centre of the sun divides the terrestrial ellipse into two unequal parts, and, by the laws of ellipti-

cal motion, the earth moves through these two portions with unequal velocities. The perihelion always lies in the smaller portion, and there the earth's motion is the most rapid. In the present position of the perihelion, spring and summer, north of the equator, exceeds by about eight days the duration of the same seasons south of it. And 10,492 years ago the southern hemisphere enjoyed the advantage we now do from the secular variation of the perihelion.* Yet Sir John Herschel has shown, that by this alternation neither hemisphere acquires any excess of light or heat above the other; for although the earth is nearer to the sun, while moving through that part of its orbit in which the perihelion lies, than in the other part, and consequently receives a greater quantity of light and heat; yet, as it moves faster, it is exposed to the heat for a shorter time. In the other part of the orbit, on the contrary, the earth being further from the sun, receives fewer of his rays, but because its motion is slower it is exposed to them for a longer time. And, as in both cases the quantity of heat and the angular velocity vary exactly in the same proportion, a perfect compensation takes place. So that the eccentricity of the earth's orbit has little or no effect on the temperature corresponding to the difference of the seasons."†

Sir John Herschel's explanation of the same uranographical phenomena, though equally perspicuous, proceeds by a different line of argument, and will, on that account, be rendered more interesting and instructive.

"It has been shown," he says, "that the *apparent* path of the sun is a great circle of the sphere, which it performs in a period of one sidereal year. From this it follows, that the line joining the earth and sun lies constantly *in one plane;* and that, therefore, whatever be the *real* motion from which this *apparent* motion arises, it must be confined to one plane, which is called the *plane of the ecliptic*. . . . . .

"But if we observe the place of the sun daily throughout the

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* We regret extremely to be, again, under the necessity of entering our dissent from Mrs. Somerville's opinion; but, to preserve the unity of our theory, we are obliged to remind our readers, that at the remote period of the earth's geognostic history above mentioned, it received neither light nor heat from the sun. This, itself, being then an opaque body.—AUTHOR.

† Connexion of the Sciences, pp. 9, 85, 86.

year . . . . . it will be found, that even in his own proper path, its apparent angular motion is far from uniform. . . . . . Such are the extreme limits, and such the mean value of the sun's apparent angular velocity in its annual orbit. This variation of its angular velocity is accompanied with a corresponding change of its distance from us. . . . . .

"It follows from this, that the real orbit of the sun, as referred to the earth supposed at rest, is not a circle with the earth in the centre. The situation of the earth within it is *eccentric*, *the eccentricity* amounting to 0.01679 of the mean distance, which may be regarded as our unit of measure in this enquiry. . . . . .

"This elliptic form of the sun's path, the eccentric position of the earth within it, and the unequal speed with which it is actually traversed by the sun itself, all tend to render the calculation of its longitude from theory difficult, and indeed impossible, so long as the law of its actual velocity continues unknown. This *law* is not immediately apparent. It does not come forward, as it were, and present itself at once, like the elliptic form of the orbit, by a direct comparison of angles and distances, but requires an attentive consideration of the whole series of observations registered during an entire period. It was not, therefore, without much painful and laborious calculation, that it was discovered by Kepler, and announced in the following terms :—'Let a line be always supposed to connect the sun, supposed in motion, with the earth, supposed at rest; then, as the sun moves along its ellipse, this line (which is called by astronomers *the radius vector) will describe* or *sweep over that portion of the whole area or surface* of the ellipse which is included between its consecutive positions; and the motion of the sun will be such *that equal areas are thus swept over* by the revolving radius vector *in equal times*, in whatever part of the circumference of the ellipse the sun is moving.' . . . . .

"The circumstances of the sun's apparent annual motion may, therefore, be summed up as follows:—It is performed in an orbit lying in one plane passing through the earth's centre, called the plane of the ecliptic, and whose projection on the heavens is the great circle so called. In this plane, however, the actual path is not circular, but elliptical; having the earth, not in its centre, but in one focus, the eccentricity of this ellipse is 0.01679, in parts of a unit equal to the mean *distance*, or *half the longer diameter of the ellipse;* and the motion of the sun in its circumference is so regulated, that

equal areas of the ellipse are passed over by the radius vector in equal times."*

As a direct sequitur from these premises, and from the attendant circumstance of the sun dispensing, at all periods, a constantly equal degree of light and heat, it follows—that as the radii vectores sweep over areas proportional to the times, the light and heat received by the earth must, likewise, be equal and proportional to the times.

According, therefore, to these unanimous and conclusive authorities, there can be no doubt as to the sun's dispensing only *a limited daily quantum of light and heat*, whose amount being known, and being subjected to examination, can be exactly appreciated; and that this fact stands on bases sufficiently firm to support whatever superstructure it may be considered expedient to raise upon it.

Now, the whole tenor of this treatise has been directed—and we hope successfully—to prove the veracity of the statements made in the first chapter of Genesis; some of the more prominent of which are, that during the *second* day of the Mosaic week, sufficient light, or the expansive principle emanating from light, was shed upon our earth to form the whole aerial body of the atmosphere, and to supply it with its constituent amount of aqueous vapour. That, during the first part of the *third* day, there was light employed sufficient to separate the waters from the dry land, by means of the heavens; and, during the succeeding portion of that day, to form the two principal classes of plants comprising the *phanogamous* division of the vegetable kingdom complete and in full fruition. And, when we contemplate these facts with relation to the limited supply of light which we *now* receive, we must agree to either the self-condemning and absurd position, that the light, as it is now constituted, could, during the limited periods of time above mentioned, form an atmosphere, separate the aqueous from the solid part of a sphere, and produce fully two-thirds of a vegetable kingdom, from the germ to their full fruition; or conform to the more rational conclusion, *that*

* Astronomy, Cab. Cyc., American edition, pp. 176—180.

when the light did perform these works, it was not then, as it now is, concentrated around the central orb of our system, to dispense a measured supply of light and heat for the purpose of sustaining and invigorating the wonderful fabric which had been produced by its instrumentality when differently situated, and directed by the wisdom and the strength of the Omnipotent; while the actual presence of these works show, evidently, that the light not only did exist, but was in itself perfect and whole, lacking nothing. With this conclusion we shall the more readily acquiesce, when it is recollected, that it is in strict accordance with the words of inspiration; and will, in the sequel, lead us to full and concurring views of the stupendous and magnificent operations of the Almighty, who, alone, could wield the movements of that important principle, and cause it first to operate in the manner he did, and afterwards to be placed wherever it was most conducive for his designs, and for the well-being of his creatures.

But there is yet another concurring testimony to be derived from the tenor of the first chapter of Genesis itself; for, as the earth revolved around the sun, *long before the period of the Mosaic week,* had the light been concentrated around the sun the moment it was willed into existence, then must it necessarily have served for signs, seasons, days, and years *from that moment;* as, in place of the earth revolving around an opaque body, it would then also have been revolving round an *illuminated* one. This, however, is not in accordance with the language of that important chapter; for no mention is made in it of these "signs, seasons, days, and years," until the fourth day of the Mosaic week, when it is expressly stated, that the sun was illuminated by the light being concentrated around it; or, as it is written, "set in the firmament of the heaven;" and from that period these seasons, measured out by the rays of the luminaries then constituted, commenced to be known to the earth, and that, too, before there was a human being to denote them!

It is, therefore, one of the clearest and best established deductions which can be drawn from the Dynamical Theory, that the light did *not,* during the first three days of the Mosaic week, occupy the place it now does in the centre of our

system; and that, too, for the sum of the concurring reasons which have been given, namely—*that if so situated it could not have done what it actually has performed.*

Should this assumption, however, be disputed, it becomes the duty of those who deny or impugn it to prove, by evidence more worthy of credit, that the light was concentrated around the sun, not only during the first three days of the Mosaic week, but also during the whole period required for the formation of the geological phenomena; and, being thus concentrated, that it could have performed what we consider we have shown to have been done by its instrumentality while it was in another condition.

It is when contemplating the primary light as existing in altogether another state or condition during the brief period alluded to, that we obtain the most invigorating views of the declarations of Scripture. For the result of our investigations is, that the subject under consideration has assumed a position from which neither human knowledge nor all the treasures of science can extricate it. These have, indeed, furnished the means of accomplishing what has already been done, and what will hereafter be brought forward to prove what we firmly believe to be the announcement of Scripture, namely—that the primary light did *not* occupy the centre of the solar system during the first three days of the Mosaic week; but as it cannot be doubted, without calling into question the evidence of our senses, that it does so *now*, science has yet to inform the world of the resources which it possesses, unaided by revelation, for explaining how the mighty change of centre was achieved; how that which, within the consecutive periods of three natural days, could cause a world to revolve, form an atmosphere, and the greater part of a vegetable kingdom, was changed in character, and compressed around a centre. We mean no disparagement to science, while it keeps within the most ample province that ever was legitimately assigned to it; and few, perhaps, more heartily admire its powers or wonder at its innumerable records, than we do; nevertheless, the truth must be manfully and unequivocally proclaimed; in this we must give forth no "uncertain sound." SCIENCE, *in all the range of its resources, knows no power capable of changing the body*

of light, which enlightens our system, from any other condition in space to that which it now has, and of compressing it around the centre which it now occupies.

It is here utterly helpless, and consequently must gladly cling to any means which may be found to extricate it from such a dilemma; this assistance can be found only *in the announcements of revelation.*

It is precisely in such an emergency, that those who believe in the words of inspiration enjoy the purest and most substantial triumph of their faith over those who do not. When science, with her innumerable resources, is completely at fault, as in this instance, they can turn with the most implicit confidence to that steady beacon which beams with undiminished splendour, and by its assistance extricate themselves amidst the intricacies which perplex and threaten altogether to confound the others.

We have all along foreseen the difficulties which we should have to encounter when we reached this part of our treatise; and were aware that these would spring from two separate sources: that the sun being *now* the sole cause of light and heat would occasion the most inveterate of all prejudices, that which arises from *ocular demonstration,* and render it very arduous to prove that it was *not always* illumined; that although the earth is now rotating before the radiant splendour of the sun, and receiving from that inexhaustible storehouse of light and heat its daily allotted quantum, it did not always do so; but that, as there was a period when neither the one nor the other had rotation, so there was an equally protracted period when the sun emitted no light.

We were fully aware, besides, that we should need to place but slender reliance on any assistance we might derive from the treasures and resources of science, which, in all other emergencies, had stood us in such good stead; for the legitimate domain of science, with respect to light and heat, is that which exists; *not* that which *did* exist.

Hitherto all the arguments in this particular branch of our subject have been directed to remove the former prejudice, and to show that the light was *not* concentrated around the sun during the first three days of the Mosaic week; consequently

they have merely amounted to *proof negative;* have tended only to demonstrate where the light was *not;* and this, we trust, we have satisfactorily accomplished, for it is indeed a very important point to attain, in consequence of the influence it will exercise over our future reasoning.

But how shall we undertake to prove *where*, or in what state the light was during those three eventful days? Where are we to find evidences of what took place when there was no mortal eye to behold it? no hand to note down its history?

The records of revelation must be our only testimony; our knowledge of the attributes of the Creator our sole principles; and a close and correct application of both to the known qualities of matter and its laws must furnish our only conclusions.

In a former part of this work we aimed at the result—as that of close deduction from the words of inspiration—that the primary light, or that which was willed into existence on the first day of the Mosaic week, was *formed complete and whole before* it was "divided from the darkness," because, when in the former state, it underwent an examination by the Omnipotent, and was found even by Him to be "good." Consequently, there was an instant of time (however evanescent affects not the argument) when as yet it was *not* "divided from the darkness," or, what is the same thing, from "attraction." That it is, in fine, the ethereal fluid which pervades all materialism* before it had been caused to vibrate—before it had produced any effect.

The almost ubiquity of this subtile creation in respect to extension throughout space, as also with regard to molecular minuteness, we have already taken great pains to demonstrate; but we would wish it to be conceived, thus pervading all space and all the pores of matter, for a moment, *without* any impulse of motion or movement having been impressed upon it: for, in this condition we must believe it to have been for a brief period, if we rely at all on the announcements of Scripture. We may imagine it to have been an invisible and delicate network, permeating all materialism, which was, when the Cre-

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* *Thirty-eighth* Theorem and evidences.

ator should see fit, to convey the magneto-electric fluid, and to produce the wonders of His handy-work!

The vast extension of this new creation and its amazing tenuity—for, that which requires to perform 768,432,749,843 vibrations before a sensation of *redness* can be excited on the retina, must be tenuous indeed! The rarefied state of the ethereal fluid has already been made the object of our admiration in this work. We have gone so far as to say, we consider it to be matter in that condition, if any such condition does exist, which is nearest akin to immaterialism; but still *it is matter*. We may imagine it, if we please, to be as many millions of times more tenuous than its computed vibrations prove it to be, but still we shall not be able to withdraw it from materialism: it would, nevertheless be a creation, be matter still; and matter, we are authorised to assert upon the stern and uncompromising dictum of science, "can neither originate motion in itself, nor diminish or alter the direction of that which it receives from other sources; and this, without any exception arising from the state or condition of the material substance—sufficient if it be *matter*.*

The *materialism* of the ethereal fluid also indicates that its elements (whatever they are) were created during the period called the "beginning;" for *then* God created the heaven and the earth, and nothing was created thereafter. Nor should the extreme exility and tension of this fluid weaken our belief in this truth in the smallest degree. The ocular revelations of the microscope show us the wondrous minuteness of organic beings, animated by life and endowed with senses; while our knowledge of these, and of the necessity for this ethereal fluid to vibrate, so as that they shall be enabled to use those senses, should lead us unfaulteringly to one of the appreciable verges of its tenuity and tension. Again, the infinitude of its vibrations, required to originate in our own minds a sensation of the various colours and their shades, should in a like manner enable us to explore its wonderful extent and rarefaction in another direction. While, as regards the probability of matter when

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* *Sixty-seventh* Theorem.

elevated into space, expanding almost into immaterialism—if we may be allowed so to express ourselves—we have only to remember what Dr. Thomson has told us respecting the air:—

"That a cubic inch of it elevated to an altitude of only 500 miles would, at the ratio of its expansibility below, so enlarge in bulk as to fill a space measuring *three thousand and fifty-three quadrillions, six hundred and thirty-five thousand two hundred trillions of cubic miles!*"

And when we consider that diminution of density or rapid increase of tenuity, as we recede from the centre, seems to be a principle affecting our sphere—the water being less dense than the earth—the atmosphere than the water—we can hardly recognize any serious objection to the belief, that there is yet another elemental body surrounding and permeating all, whose exility may have increased at the same or some greater ratio, and whose *tension* is as wonderful as its *tenuity*.

In the case under consideration we appear to have reached the very confines of materialism; yet, as respects the power of this to impart spontaneous motion, it will not afford us any assistance, for we are still within its boundaries; and, as "matter cannot spontaneously originate motion in itself," so neither could the ethereal fluid have done so, even after it had passed in review before the searching eyes of the Almighty, and he had pronounced it to be "good!" Had revelation then ceased or been silent, all the resources of science could not have extricated us from our present difficulty—could have imagined how motion was acquired by that which had it not—how the ethereal fluid was ever made to vibrate! But thanks be unto Him who doeth all things wisely and well, we are not thus without aid; we are not left to conjecture how this transformation was effected, and how that which was inert, immovable matter, was made to vibrate with almost life-giving effect, for we are informed by the testimony of him who cannot have erred, that "God," himself, "divided the light from the darkness."

In the elucidation of that part of our subject which relates to the formation of the atmosphere, we took particular pains to prove, and we did so partly on account of the influence which

we foresaw it would exercise on this more difficult portion, that in the scriptural language there used, to *divide* any thing from another, as in the instance of the waters which were *under* the firmament from the waters which were *above* the firmament, it signifies, that the result produced is to confer on the two separated portions *different directions of motion in space.* And in the antecedent case more immediately under consideration, we not only do not recognize a motive why we should suppose any other result to have been accomplished by the "division of the light from the darkness," but very strong reasons for supposing that such really did take place, and that the light had thereby a state or condition conferred upon it *which caused it to tend in a direction opposite to that to which darkness tends.*

We have shown—and we trust satisfactorily—that darkness in scriptural language, signifies *attraction;* and, therefore, as "attraction is the name of an unknown cause producing a known effect," and that effect is "to occasion motion in material bodies, or molecules towards a centre;"* hence it follows, that light, by being divided from the darkness, or from that "unknown cause," had a state or condition permanently impressed upon it, which made it produce effects *diametrically opposed* to that from which it was divided: to occasion motion in material bodies or molecules *from* the centre *to* the circumference; or, what is the same thing, to occasion *expansion.*

Thus far the subject is almost self-obvious, and has presented little of difficulty; but when we attempt to assign the centre or centres, or foci from whence *the primary light commenced to vibrate,* we find ourselves constrained to adopt a line of argument partaking even more of the metaphysical; whilst reflection points out to us, on the other hand, that *vibratory motion must have had a point of origin.* When a *force* propends *towards* a centre or centres, and there are well-known and recognized centres through which the force passes—such as the sun, the centre of attraction of our system, or pretty nearly so, and the centre of the earth for that of terrestrial

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* *Seventieth* Theorem and evidences.

attraction—the mind is at no loss, is not in perplexity: but this is not the case when the enquiry has reference *to a centre or centres which no longer exist;* and in this peculiar condition, that respecting the *primary light* is especially involved; for the sun, which is now the centre of light and heat, was *not* the source from whence the primitive light proceeded. We are told so by revelation; and, during the course of this treatise, it has been shown, that from *that* centre, and circumstanced *as it there now is*, it could not have produced those works which, it is admitted, the primary light was made instrumental in producing.

Nor can our utmost unaided ingenuity discover *where* its centre or centres were. Once admitted that it was *not* where it now is, we cannot, unassistedly, tell *where* it may have been; while we are constrained to suppose that, that which, by vibration, caused expansion, must have had foci whence those impulses commenced. Yet this very conviction of utter helplessness in our own resources, and in those of science, may be the means of leading us nearer to the true explanation of the question, or to an approximative conclusion satisfactory to the mind.

We have already repeatedly alluded to the almost inconceivable tenuity of the ethereal medium—to the quasi ubiquity of light throughout the universe—and to the minuteness of its molecules, shown by the rapidity of its vibratory motion. Nevertheless, being *matter* still, it must have had a generator of motion from a source *not* material; and this, we are precisely informed, was the case. "GOD divided the light from the darkness." Whatever degree of minuteness we may think proper to attribute to the molecules which constitute the all-pervading ethereal fluid, the primary light of the first day—and minute, all investigations prove, they must be—still, GOD, as a spirit, is more ubiquous far, and is, in reality, the only power capable of imparting motion to molecules such as they; the alone centre whence the vibrations could have originated! Daniel, indeed, assures us "that light dwelleth with HIM."*

We have thus—in the best frame of mind, and guided alike

* Daniel ii. 22.

by the announcements of revelation and the more recent conclusions of science—sought for the source of motion of the primary light, and we have been led up to the CREATOR as the centre and source of that light; and thus we have been transferred from materialism to immaterialism by the only channel of connection in the universe between the two—GOD himself; consequently, our reasoning, now, must have respect to the attributes of that great Being, as the means best adapted for learning anything respecting the light, when it issued forth to perform, under his unerring guidance, those stupendous works which are still the memorials of its power.

In this we are, happily, not—Athenian-like—obliged to erect a "temple to the unknown God." God is acknowledged to be "a spirit, infinite, eternal, and unchangeable in his being, wisdom, power, holiness, justice, goodness, and truth."* The first three of which glorious attributes, being incommunicable, could not be conferred, in any degree, on *matter*. But when the remaining six, which are communicable, are contemplated, they are found to be those which alone can determine the centres or foci of the ethereal fluid, and from whence alone the impulses could have proceeded which produced works so characterized by wisdom, power, justice, goodness, and truth. "God said, Let there be light, and there was light. And God saw the light that it was good. *And God divided the light from the darkness.*"

Nor is this conclusion, which seems inevitable, altogether without precedent or analogy. We find it recorded in a previous part of this same chapter, that *before* there was *light*, or an ethereal fluid, when *motion*, as a counteracting influence to darkness or gravitation, was necessary, it pleased "the spirit of God to move upon the face of the *waters*;" a revelation, which, wonderful although it be, is in perfect harmony with the subsequent announcement, that when *light* or the ethereal fluid was formed, that is, when a medium of impulse of greater tenuity than water was required to suit the organisms which were to be introduced into creation, it was "God who divided

* Westminster Confession of Faith, pp. 181, 400; and Catechism of the Church of Scotland, p. 5.

the light from the darkness." For if we admit, what indeed without renouncing all reliance on the words of revelation we cannot consistently deny, that in the former instance God produced direct effects upon the dark and atmosphereless mass of waters which surrounded the enchoate globe, we cannot but admit that He might, when he thought proper, have impressed *motion*, by his own immediate influence, upon the molecules of the newly-formed ethereal fluid, or the light of the first day of the Mosaic week; and more so, when we have the assurance that he did do it, upon the authority of His own word. And thus by a shorter and a straighter path we have reached the same point, and come to the same conclusion which we did before.

Neither do we offer any disparagement to science by having, in this instance, had recourse to final causes. We could not do otherwise, unless we had resolved to leave this part of our discourse unfinished. For, with all the predilection which we entertain for the scientific division of our evidences, *we carried its proof to the very extremity of materialism;* by its assistance we traced matter until it almost vanished, and became so tenuous as scarcely to be appreciable by the senses; but even when we had reached this, when on the very verge of materialism, our companion reminded us, that being still within the bounds of matter and the domains of gravity, the stern and unbending law of inertia forbade us to believe, that "spontaneous motion could by any means be engendered in it;" from the resources within her reach all further hope of assistance was in vain; and that the origin of motion of the ethereal fluid must be sought for where attraction has no power, LIGHT and HEAT having been removed from under its dominion.*

Farther on this subject we dare not proceed, without incurring the risk of drawing aside that veil which we are prohibited from even touching. Neither may we, with consistency, at this juncture undertake to prove, that there was, on its first formation and division from the darkness, an irresistible rush of light, akin to that of the waters, when those of the primitive ocean, on being made to revolve, swept onwards from the

* *Forty-sixth* Theorem.

poles to find their level of rotation, or like to the atmospheric elements, when the firmament, at the word of command, stretched itself throughout the expanse of its destined space; although strict analogy, and the mighty labours which the light had to perform on the first day of the Mosaic week, lead us to suppose that such was really the case; but of this we have no *direct* testimony, and shall, therefore, be obliged to approach this part of our subject indirectly, or by the differential method; trusting, by that means, to make manifest the irresistible influence which the primary light put forth, by the effects which it has produced: the stupenduous works, then accomplished by its instrumentality, which still remain to constitute the most undeniable monuments of its amazing power.

In our endeavour to make good our point by this indirect approach, and before we proceed any further, it may be as well to recapitulate once more the expression of the equipoising forces which restrain the earth in its orbital path around the sun. These constitute the subject of the *fourth* Theorem, which states, "*That the orbital revolutions of the Earth and other planets around the sun, almost in the plane of its equator, and of the satellites around their primaries, are caused by the combination of the sun and the planets' mutual attraction, and an original projectile impulse; whilst the whole system is connected and regulated by the law, of the squares of their periodical times being proportional to the cubes of their mean distances from the sun. That the same laws maintain the comets in their more elliptical orbits, their eccentricity depending wholly on the direction and force of the original impulse which put them in motion.*"

In continuation we shall reproduce the words of the *third* Theorem, in consequence of the direct bearing which they have on our present argument:—"*That the Earth has a double movement in space; one by which it revolves around its own axis in 24 hours solar time, or in 23 hours 56′ 4.09″ sideral time, and another movement whereby it performs its periodical revolution, in an invariable plane, around the sun, in what is termed the tropical year, of 365 days 5 hours 48′ 49″·7. That these two motions are entirely independent of each other. And that if the Earth did receive its double movement from a*

single impulse, it is considered, by computation, that the impulse must have passed through a point about twenty-five miles from its centre."

The application of the Dynamical Theory to the astronomical data which we have just recapitulated, and the blending of some of the best established of these announcements with the conclusions which we have arrived at during the course of our investigations, lead to two distinct but equally important results.

With respect to the *direction* in which it is apprehended that the primary projectile impulse was impressed upon the earth, it will be obvious, that if this did not—as we consider we have satisfactorily shown it did not—simultaneously cause the earth's motion in space and its rotation around its axis; but, that the former preceded the latter *in time* by the whole period necessary for the deposition of the principal portion of the strata, then, the force which caused the earth and other planets to revolve around the sun, and all around their common centre of gravity, must have been of a description which (in connexion with the other existing laws of matter) would cause them to revolve around each other, and all around the common centre alluded to, *without* rotating around *their individual axes*. The deduction itself is so necessarily evident as scarcely to require either explanation or comment; but the *direction* of the impelling force is by no means so easily determined; nevertheless we are inclined to consider it to have been akin to that power which, ages afterwards, caused the orbitally revolving earth to rotate around its axis, without affecting the forces which maintained it in its predetermined path through the heavens, and which, no doubt, impressed similar motion on the other primary bodies of the system around their respective axes.

As regards the *diurnal motion,* which we have all along maintained was *not* communicated to the earth coevally with its orbital impetus, otherwise we could not have accounted satisfactorily for the geological phenomena which bestrew its surface, we shall now have to go more into detail, in order to substantiate, by astronomical data, the position which other

natural evidences occasioned us to assume, and which, hitherto, they have enabled us to maintain.

Attraction, one of those counterpoising forces which retain the earth in its orbital revolution around the sun, is (as has already been quoted) thus described by Sir John Herschel—

"The direction of attraction at any point of the orbit of each planet, *always passes through the sun.* No matter from what ultimate cause the power which is called gravitation originates, be it a virtue lodged in the sun as its receptacle, or be it pressure from without, or the resultant of many pressures or solicitations of unknown fluids, magnetic or electric ethers, or impulses; still, when finally brought under contemplation and summed up into a single resultant energy, its *direction* is from every point on all sides towards the sun's centre."

Being made aware that such is the direction of one of the divellent forces which, acting on the earth in motion in the heavens, retains it in its destined orbital path; and bearing in mind the deliberate conclusion we have previously come to—"*that these two motions are quite independent of each other,*" inasmuch as *that there was duration in time, between orbital revolution in space and diurnal rotatory motion, sufficient to admit of the deposition of the greater part of the stratified formation of the earth's outer crust;* we must come to the conclusion which we did before, namely, that the other divellent force which is required to maintain the earth and other spheres in their orbits, must have been communicated at right angles, or tangentially, to that which is occasioned by the centripetal force of gravity, and so have caused the resultant direction in which the spheres travel in space.

This conclusion is most interesting, inasmuch as it points out, in language which can neither be set aside nor misunderstood, that the force which acted at right angles to the direction of gravity, and by overcoming its aggregate inertia caused the earth ever to be disposed, but, owing to the perfect equipoise, never able to fly off at a tangent from its path in space, must have been similar to that which we assume to have emanated from the primary light, when introduced into the material universe, and divided from the darkness, on the FIRST day of

the Mosaic week; because the result of this last was also to communicate motion in a direction tangentially to the molecular attraction passing through the earth's centre, and to overcome the inertia of its recumbent matter. It was not, however, merely to reach this conclusion, notwithstanding its importance, that we thought proper, at present, to point the attention to these facts. We more particularly desire that the mind should be directed to the circumstance itself, of the *just equipoise of the two divellent forces*, and to the knowledge, that to this we are indebted for the steadiness and certainty with which the earth performs its annual revolution around the sun; consequently, that any increase or decrease of either of those counterbalancing forces would be destructive of that security; would, in reality, disturb the whole economy of the solar system.

Now it is, when this conviction is strongly impressed upon the mind, that we recognise, most clearly, the importance of the conclusion we previously came to, namely—that there was a protracted period during which the earth did *not* rotate around its axis; but that it had *diurnal* motion impressed upon it, in common with the other spheres of the system, at a comparatively recent period: and that thereby such a centrifugal impetus was communicated to the earth as to raise its continental ridges and mountain chains, to depress the oceanic hollows, and to occasion the previously circumfluent waters, in rushing from the poles, to retire within these receptacles: because, as it has already been observed, if neither of the forces which restrained the earth in its orbital path could, without suffering disturbance, admit of either increase or of decrease, then we are constrained to conclude, that the force which caused the orbital revolving earth to rotate diurnally, could not have impinged upon it, equipoised as it was, either in the direction of gravity, or in that of its divellent counterbalancing force; and if it could not have impinged upon it in either of these two directions, neither could it have done so in any intermediate one; because this, too, would have tended, as far as it went, to have augmented one of the equipoising powers, to the certain overthrow of the other.

We are thus wholly excluded from assuming, that the force

which caused the earth to revolve around its axis impinged upon it in the direction of the centripetal or centrifugal influences, or in that of any intermediate point between the two; although these, nevertheless, constitute the *directions* in which all forces act which proceed in straight lines, and produce effects directly either *to* or *from* their own centres; or which could have affected the earth in any line perpendicular to its axis.

SECTION IX.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XXXVIII.

Preparatory observations. Unique nature of the force which occasioned the protorotation of the earth, and other spheres of our system. Supposed to be identical with electro-magnetism. This description of force defined, and described more minutely from scientific sources. Also the movement of rotation which frequently accompanies the exhibition of this kind of electricity. Confirmatory evidence deducible from the single motion, or non-diurnal rotation of the moon. This satellite fully described according to the latest telescopic discoveries. Concluding inferences.

THE conclusions which we came to at the close of the preceding chapter are very important, and are likely to exercise considerable influence over our future arguments. Convinced of this, as well as of the certainty of the non-rotating sphere having been caused, by a commensurate influence, to revolve around its axis, we are shut up to the alternative of supposing, *that this effect was produced by a force which acted in a manner distinct from any we have yet had occasion to contemplate;* one, for instance, which, while it proceeded in a direction *parallel* to the earth's axis, was capable of sending forth its resultant effects *at right angles* thereto; and, fortunately for our hypothesis, and the fate of this theory, there has been discovered, lately, a force which *causes rotation in planes perpendicular to the line of its direction;* and which, therefore, completely corresponds with the description of force of which we are in quest.

This unique impelling power belongs to a class of pheno-

mena hitherto only casually noticed, but to which we must now direct the attention, and endeavour to make it known to our readers, as far as the present state of information regarding it will permit; while we take occasion, even at the commencement, to engage their favour and consideration by observing, that this lately discovered force possesses peculiar interest, when considered with relation to our own cosmographical views; for, besides the important circumstance of its producing motion in a direction at right angles to the line of its own progress, it emanates from the subtile fluid, electro-magnetism; an influence which, in turn, is considered to be of a kin to light and heat*—the element, whose introduction into the material universe we consider to have been the immediate secondary cause of the rotation of the earth, and the other spheres around their respective axes; thus presenting to the contemplative mind a most convincing testimony of the power of that Omnipotent Being, who, after having wielded this potent influence by his word, and having caused it, in the condition it then was, to produce the stupendous and fundamental works of the first three days, could, afterwards, by a mere command, concentrate what remained of the subtile element around the sun, to impart light and warmth, and life-fostering influences, for ever thereafter, to the myriads of his created beings! This is a theme worthy to be contemplated, and sure to elevate the soul to juster and more comprehensive conceptions of the all-wise Creator, who made every thing in perfect goodness, and by his wondrous power. But we must return to the line of proof which we are at present pursuing.

The *sixty-third* Theorem states, "*That* ELECTRO-MAGNETISM *(electricity modified by the physical influences peculiar to certain substances), by overcoming retardation arising from friction, and the obstacle of a resisting medium, maintains perpetual motion. That the force emanating thus mutually from the electric current and the magnetic needle, acts at right angles to the electric current. 'Such circumferential action, arising from the tangential direction of two opposite forces,'*

* "The discoveries of Oersted, Seebeck, and Faraday show an intimate connexion between these unseen fluids."—Dr. Thomson, p. 278.

being unlike any other power hitherto discovered; for, all other known forces emanating from a point, and acting upon any other, impel in the direction of a line joining these two points."

The following are some of the philosophical conclusions on which the foregoing theorem is founded; they place this interesting subject in distinct points of view, and may, therefore, tend more fully to illustrate the peculiar character of the force in question, on which account we beg the attention of our readers to them.

Mrs. Somerville observes—

"The disturbing effects of the aurora borealis and lightning on the mariner's compass had long been known. In the year 1819, M. Oersted discovered that a current of voltaic electricity exerts a powerful influence on a magnetized needle. This observation has given rise to the theory of electro-magnetism—the most interesting science of modern times, whether it be considered as leading us a step further in generalization, by identifying two agencies hitherto referred to different causes, or as developing a new force, unparalleled in the system of the world; which, overcoming retardation from friction, and the obstacles of a resisting medium, maintains a perpetual motion, often vainly attempted, but apparently impossible to be accomplished by means of any other force, or combination of forces, than the one in question. . . . . .

"All experiments made in this branch of science tend to prove that the force emanating from the electric current, which produces such effects on the magnetic needle, acts at right angles to the current, and is, therefore, unlike any force hitherto known; the action of all the forces in nature being directed in straight lines, as far as we know; for the curves described by the heavenly bodies result from the composition of two direct forces, whereas that which is exerted by an electrical current upon either pole of a magnet has no tendency to cause the pole to approach or to recede, but to rotate about it. If the stream of electricity be supposed to pass through the centre of a circle whose plane is perpendicular to the current, the direction of the force exerted by the electricity will always be in the tangent to the circle, or at right angles to its radius;* conse-

* In a note Mrs. Somerville adds: "when a stream of positive electricity descends from *p* to *n* in a vertical wire, at right angles to the plane of a horizontal circle, the negative electricity ascends from *n* to *p*, and the force exerted

quently, the tangential force of the electricity has a tendency to make the pole of a magnet move in a circle round the wire of the battery. Mr. Barlow has proved that the action of each particle of the electric fluid in the wire, on each particle of the magnetic fluid in the needle, varies inversely as the square of the distance."*

Sir John Herschel says—

"*Magnetism* and *electricity*, which had long maintained a distinct existence, and been studied as separate branches of science, are, at length, effectually blended. This is, perhaps, the most satisfactory result which the experimental sciences have ever yet attained. All the phenomena of magnetic polarity, attraction, and repulsion, have, at length, been resolved into one general fact, that two currents of electricity, moving in the same direction, repel, and in contrary directions attract each other. . . . . .

"And, to obliterate all traces of that line of separation which was once so broad, we are now enabled, by the great discovery of Oersted, to communicate at, and during pleasure, to a coiled wire of any metal, indifferently, all the properties of a magnet! its attraction, repulsion, and polarity; and *that* even in a more intense degree than was previously thought to be possible in the best natural magnets. . . . . .

Farther on he continues—

"The connexion of magnetism and electricity had long been suspected, and innumerable fruitless trials had been made to determine the question in the affirmative or negative. . . . . . Of all the philosophers who had speculated on this subject, none had so pertinaciously adhered to the idea of a necessary connexion between the phenomena as Oersted. Baffled often, he returned to the attack; and his perseverance was, at length, rewarded by the complete disclosure of the wonderful phenomena of electro-magnetism. There is something in this which reminds us of the obstinate adherence of Columbus to his notion of the necessary existence of the New World; and the whole history of this beautiful discovery may serve to teach us reliance on those general analogies and parallels between

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by the current makes the north pole of a magnet revolve about the wire in the direction of the arrow heads (from left to right), and it makes the south pole revolve in the opposite direction. When the current of positive electricity flows upwards from n to p, these effects are reversed."

* Connexion of the Sciences, pp. 328, 329.

great branches of science, by which one strongly reminds us of another, though no direct connexion appears; as an indication not to be neglected of a community of origin."*

We are informed by the compilers of the Encyclopædia Britannica, that—

"The cultivation of the new science of voltaic electricity withdrew the attention of experimental philosophers from that of ordinary electricity, ... but the discoveries of Galvani and Volta were destined, in their turn, to pass into the shade, and the intellectual enterprize of the natural philosophers of Europe was directed to new branches of electrical and magnetical science. Guided by theoretical anticipations, Professor H. C. Oersted, of Copenhagen, in 1820, laid the foundation of the science of *electro-magnetism*. He found that the electrical current of a galvanic trough, when made to pass through a platina wire, acted upon a compass needle placed below the wire; and, upon repeating the experiment, he discovered the fundamental law, that *the magnetical effect of the voltaic current had a circular motion round the conductor*, or the wire through which the current passed. M. Ampere, of Paris, soon afterwards made the important additional discovery, that two wires, conducting electrical currents, when suspended so as to be capable of motion, *attracted* each other when the currents moved in the *same direction*, and *repelled* each other, when they moved in *opposite* directions; or, to express the fact more simply, *two points of electrical currents repel each other by their similar sides, and attract each other by their opposite sides;* so that, as Prof. Oersted remarks, *an electric current contains a revolving action, exhibiting every appearance of polarity.*"†

"It was conceived," says Professor Whewell, "that the whole of natural philosophy must consist in investigating the laws of force, by which particles of different substances attracted and repelled, and thus produced motions, or vibrations *to* and *from* the particles. Yet, what were the next great discoveries in physics? The action of a galvanic wire upon a magnet; which is not to attract or repel it, but to turn it to the *right* and *left;* to produce motion, not to or from, but *transverse* to the line drawn to the acting particle."‡

In addition to what we have already offered, and in the

* Discourse on Natural Philosophy, Cab. Cyc. pp. 324, 326, 339, 340.
† Article Electricity, pp. 573, 574. ‡ Bridgewater Treatise, p. 369.

absence of all direct proof as to the cause of the earth's diurnal rotation, it is satisfactory to be in possession of evidence somewhat corroborative of the opinion we have given on the subject. We allude to the fact of rotation around an axis being one of the most constant developments of electro-magnetism; and, although, in strict reasoning, this can be offered only as *presumptive* evidence, yet it does not fail to exercise considerable influence in favour of the conclusion we have come to, THAT THE ROTATION OF THE EARTH WAS ONE OF THE EFFECTS OF THE DEVELOPMENT OF THE HIGHEST POSSIBLE DEGREE OF ELECTRO-MAGNETISM EVER DISPLAYED IN OUR SYSTEM.

The facts alluded to form the evidence for the remaining portion of the *sixty-third* Theorem—"*That in all the experiments undertaken with a design of eliciting the phenomena of electro-magnetism and of magneto-electricity*, ROTATION ROUND AN AXIS *is generally found to accompany them.*"

As the experiments on which these conclusions are based are most interesting, a brief description of a few of the most celebrated will, no doubt, be perused with pleasure, and tend to strengthen our convictions.

"Rotatory motion," observes Mrs. Somerville, when treating of electro-magnetism, "was suggested by Dr. Wollaston. Dr. Faraday was the first who actually succeeded in making the pole of a magnet rotate about a vertical conducting wire. In order to limit the action of the electricity to one pole, about two-thirds of a small magnet was immersed in mercury, the lower end being fastened by a thread to the bottom of the vessel containing the mercury. When the magnet was thus floating almost vertically with its north pole above the surface, a current of positive electricity was made to descend perpendicularly through a wire touching the mercury, and immediately the magnet began to rotate from left to right about the wire. The force being uniform, the rotation was accelerated till the tangential force was balanced by the resistance of the mercury, when it became constant. Under the same circumstances the south pole of the magnet rotates from right to left. . . . . .

"The wire has also been made to rotate around the magnet, and even a small battery, consisting of two plates, has performed the rotation. Dr. Faraday produced both motions at the same time in a vessel containing mercury; the wire and the magnet revolved in

one direction about a common centre of action, each following the other.

"The next step was to make a magnet, and also a cylinder, revolve about their own axes, which they do with great rapidity. Mercury has been made to rotate by means of voltaic electricity, and Professor Ritchie has exhibited in the Royal Institution, the singular spectacle of the rotation of water by the same means, while the vessel containing it remained stationary. . . . . .

"It appears," in fine, "that the principle and characteristic phenomena of the electro-magnetic science are, the evolution of a tangential and rotatory force exerted between a conducting body and a magnet; and the transverse induction of magnetism by the conducting body in such substances as are susceptible of it."*

We learn from the Encyclopædia Britannica that,

"The discovery of thermo-electricity by Dr. Seebeck in 1822, gave a new impulse to this branch of science," for, "in the same year in which he made this remarkable discovery, the rotation of a magnetical needle round an electrical current, and of a body transmitting an electrical current round a magnet, were exhibited in a series of beautiful and highly ingenious experiments by Dr. Faraday, whose subsequent discoveries place him at the head of the cultivators of this most interesting science.

"These experiments were followed by those of Arago, Barlow, Seebeck, Herschel, and Babbage, in which a revolving plate of copper gives a rotatory motion to a magnetic needle conveniently suspended; but notwithstanding the ingenuity and talent with which this subject was treated by these eminent individuals, it is to Dr. Faraday that we owe the complete analysis and explanation of this curious phenomenon."†

Somewhat further on, in the same work, it is stated that,

"This tendency of points to discharge their electricity against the surrounding air enables us to perform some beautiful electrical experiments, in which the motion of rotation is effected.

"The *Electrical Orrery*, as it is called, is founded on this principle. A spherical ball of metal S, representing the sun, has its inner concave surface supported on a pivot on the top of an insulated

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* Connexion of the Sciences, pp. 330, 333.

† Article Electricity, p. 574.

stand. From the ball S extends a wire, the turned up extremity of which supports upon a pivot another ball E, which represents the earth, having a wire passing through it, and carrying at one end a smaller ball M, representing the moon, while the other is bent into a sharp point; a sharp point H being also fixed to the arm E F. If these balls are electrified by a chain which connects them with the prime conductor, the discharge from the point H will give a rotatory motion to the arm to which is affixed the earth E, while the electrical discharge from the point N, will give a rotatory motion to the moon M round the earth E. In this manner the moon revolves round the earth, while the earth and moon together are carried round the sun."*

Before closing the evidence for this part of our argument, we cannot refrain from repeating the following very significant questions put by Professor Nichol, although so recently given:—

"As before," he observes, "*there* are the planets revolving around the sun in stated courses, each having part in the living mechanism, of which gravity is the immediate sustaining power. But certain general facts, or laws, instantly strike the eye, not recognized by Copernicus as wonderful, and certainly not explained by gravity, considered merely as a *sustaining* power. Why, for instance, do these bodies all move nearly in circles, *i. e.*, in ellipses of the most trifling elongation? Gravity would sustain them, although moving in any ellipse. Why do they revolve all in the same direction, viz., from west to east? The direction of their motion is of no consequence to gravity. Why do the satellites of the primary planet, partake uniformly of the same law? Why does every orb, planet or satellite, rotate on its axis, in the very direction of its orbital revolution, which also is that of the rotation of the sun?"†

Following up these very pertinent enquiries, and confessing, that exclusive adherence to the laws of gravitation, however comprehensive they may be, will avail us little or not at all in affording us any answer to them, we take occasion to quote the words of Dr. Faraday, as containing, in our opinion, the germ of the true solution, when he asserts:—

* Article Electricity, pp. 591, 592.

† Contemplations on the Solar System, pp. 101—102.

"That the magnetic force acts upon the ray of light always with the same character of manner, and in the same direction, independently of the different variety of substances, or their states of solid and liquid, or their specific rotative force, thus showing that the magnetic force and the light have a direct relation."

And, in fact, every proof which can be adduced on this subject tends more and more to confirm us in the belief, that from the introduction of the primary light into the material universe, and its division from the darkness, on the first day of the Mosaic week, arose the most stupendous of all instances of electro-magnetic rotation—that of the sun and its attendant orbs around their respective axes; and, that it was the same principle, sent forth at a far anterior period in the history of creation, which occasioned the more simple orbital motions of the spheres of our solar economy, and of all the other, then unillumined, systems of the universe.

In further corroboration of what has now been stated with respect to the *description of force* which we consider to have occasioned these effects, namely—the rotatory motion of the earth and other primary planets—and which may be looked upon as presumptive evidences of a positive character, we shall adduce an instance of the most confirmatory kind, although partaking of an entirely opposite nature, proof *negative*, or that which is afforded by a well defined exception to the general law with which we have recently been so conversant; we allude to the MOON's motion; our attendant satellite, which performs its double revolution by means of *one* motion in space; that around the earth in 27 days, 7 hours, and 43 minutes.

In order to prepare the mind for what we may have to say on this subject, we consider it desirable to recapitulate the *ninth* Theorem; exclusively dedicated to our companion in space—which is therein stated to have *a triple revolution; one by which it accompanies its primary around the sun, and a binary movement (performed by the same motion in 27 days, 7 hours, 43′ 11″) consisting of its sidereal path around the earth and rotation around its axis. That owing to this double revolution by a single movement, together with its libration,*

and slight obliquity of axis, the same hemisphere, increased by a narrow zone occasionally seen on either side, presents itself invariably towards the earth. And that no indication of either continents or oceans presents itself on the earthward disc, although it affords manifestations of being extremely mountainous, the elevations appearing to have originated from volcanoes, now extinct."

From the very moment of its darkened existence, and for ages before rotatory movement had been impressed upon the earth, *the moon must have performed the identical orbital motion which it still continues to do;* consequently, the fact of its remaining unaffected when the material light, by being introduced into the universe, and, by its expansive influence, had conferred an additional motion on the primary planets, shows, in language which cannot be misunderstood, that there was something *peculiar* in the *new propelling force* which was then introduced into the creation. It must have been wholly different from *attraction*, which, disregardful of the constituent materials of bodies—acts upon all *merely according to their mass.* But if the new force which emanated from the primary light, was not thus impartial and indiscriminate, *it must have belonged to those which act by election;* the constituent elements of the mass, on which they impinge, entering so thoroughly into the operation, that on them it depends almost entirely whether action takes place or not. Of this description of force there are two varieties known—MAGNETISM and CHEMICAL AFFINITY. Although by some it is considered, that those two influences are merely modifications of the same power; yet, they not only can, but in this case they do require to be treated of separately; the latter degree, *chemical affinity*, being entirely restricted to intermolecular movements, which, by it, are caused to take place in bodies within the boundaries of each particular sphere; circumscribed, as it were, within the economy of a world; while *magnetic,* and certainly *electro-magnetic* influences seem to extend throughout the whole range of each system. *Chemical affinity* has the molecules of an orb within its grasp; *electro-magnetism* has, for its dominion, the orbs themselves, the molecules of a system; consequently, we can have no hesitation in eliminating *chemical* affinity,

from the present argument, and fixing our undivided attention upon its more comprehensive congenial power—ELECTRO-MAGNETISM.

This, it is well known, is so far dependant for its action on the peculiar elements of the body with which it is brought into contact, that on some *it exercises no influence whatever.* Now it is certain that there was a period, measureable by the *time* necessary to form the materials of the stratified crust of the globe, during which the world had no rotation around its axis; that during those protracted ages, the moon revolved around the earth, and its own axis, in the precise orbit and by the same simple motion with which it continues still to perform that double movement in space; and, that while it was thus engaged, there overcame a great change upon the earth which it attended in its path through the heavens. The earth being made to revolve around *its* axis without experiencing either the slightest derangement of its orbit, or sensation in its measured way, as it wheeled around *its* primary, the sun; and what is still more remarkable, without the smallest sensation being perceived by the moon, or any change produced upon its original motion. The latter continued its monthly course around the earth, with as imperceptible a variation as the earth experienced in its more protracted circuit around the sun. Therefore we are thoroughly justified in concluding, that the force which wheeled the earth around its axis without acting on its orbital motion, or upon its attendant satellite, *was of that description which acts by* ELECTION; and *that the moon did not contain the peculiar materials which were required to render the then newly-formed force effective;* but, on the contrary, that the earth and all those bodies which have rotatory motion, did possess those qualifications and were acted upon accordingly. What those qualifications are, it may be somewhat difficult to determine; nevertheless, we think we are not wholly without the data whereby to hazard a pretty correct conjecture.

So far we are borne out in our assumption by facts, and constrained to believe, that the force employed was altogether different from attraction, which manifests no affinity whatever, acts in straight lines, and exercises a mutual, indiscriminate

power, in proportion merely to the mass of the respective bodies; and we are, therefore, the more easily led to consider, that the new force acted tangentially, and also had regard to the peculiar nature of the elements composing the bodies with which it was brought into contact. Such a force, possessing magneto-electro energies, and impinging on the solar system, in the direction we have supposed it to have done with respect to the plane of the ecliptic, would produce rotatory motion in some spheres, while it left others to revolve around their primaries *wholly unaffected by its presence;* the rotating spheres moving at right angles to the line in which the expansive force travelled, when it came into contact with them.

Stretching somewhat beyond the domain of rigidly established conclusions, we have only to suppose, as indeed we are not wholly without authority for doing so, that the concentric layers of strata, deposited from the primitive ocean in certain order of super-position, with interposing layers of aluminous material, performed a very important part in producing the momentum which overcame the inertia of our sphere; and in combination with the primary light, caused the earth to revolve upon its axis. We know, from actual tests, that currents of electro-magnetism continue to flow around the globe, and that alternating layers of matter, when immersed in and surrounded by dilute acidulous water, contribute to the development and circulation of the subtile magnetic fluid;* while, on the other hand, we have only to contrast the conjectural difference in the constitution of the moon's exterior, supposed to be devoid of oceans, and where, consequently, there could neither have been depositions, nor concentrated strata, to have something like a clue to assist us through the labyrinth, and to comprehend how the great proto-electro-galvanic current, which was willed into existence on the first day of the Mosaic week, may have met with the requisite materials encircling the earth (and other spheres possessed of diurnal motion) to enable it, conjointly with these prepared materials, to cause each to rotate around its axis; although the same universal current *might have passed by the*

* *Sixty-fourth* Theorem and evidences, to which please refer.

moon without producing the slightest effect upon it, but have allowed it to continue in its original double rotation by a single motion.

The concurring circumstances of the seeming absence of oceans or other collections of water on the moon's surface; the consequent impossibility of there ever having been any striform depositions there; and the conclusion we arrive at, from the scarped and rugged appearance of its mountain masses, that they have not been filled up or rounded off by water-borne debris;—a description of which, as far as the eye, assisted by the most space-penetrating telescopes, is capable of descrying, we intend to lay before our readers—are coincidences—when taken in addition to its non-rotation, and compared with an opposite state of geological development on the earth and its diurnal rotation—of too great importance to be allowed to pass without special notice.

We consider them, indeed, to be *very strong corroborations of the Dynamical Theory;* and, if thoroughly investigated, capable of designating more clearly the special agency made use of by the Creator to turn this great globe, and all other rotating spheres around their respective axes. This, as we have all along maintained, was the primary light, when it was first tansformed into the expansive influence; and we are also as fully convinced, that the stratiform masses of the earth's outer crust performed a very important part in this powerful leverage. That, in fact, this was one of the many co-purposes for which these concentric stony masses were originally formed by deposition during ages, and while as yet the earth had no movement around its axis.

Nor need any convictions, which these reflections may have raised in our minds, be damped by the apparent incompatibility of the results compared with the cause. We mean as regards *an instantaneous and uniform motion, and a continued force of three days;* for, as we have been made aware, "one of the most usual features in electro-magnetic experiments is, that after a short while, and the attainment of a certain equilibrium, a *continued action* produces a *uniform motion.*"*

* Connexion of the Sciences, 3rd edition, p. 330.

In order to fortify our impression as to the correctness of the position we have assumed, namely, that of the moon having been exempted from the influence of the electro-magnetic current, put into circulation in the heavens by the proto-vibration of the ethereal fluid—when the light was divided from the darkness—we shall proceed to make our readers aware, that those enduring monuments of rotation round an axis, in diurnal revolution, after a lengthened period of quiescent deposition, such as continents and oceans, do not exist in the moon; and with this design we take occasion to transcribe the following graphic delineation—the latest intelligence from our nocturnal companion, when subjected to the scrutiny of those distinguished individuals who, by their skill and munificence, and by the aid of powerful space-penetrating telescopes, have themselves reported upon it, and enabled others to do the same, with almost topographical minuteness.

In offering this selenic description to our readers, while we apologize for the unavoidable curtailment of some of its passages, we would remind them of the safeguard which they and we possess in the scientific celebrity of the writer, and the little probability there is, on that occount, of his having been led into any misconception of what he so well describes:—

"THE CONSTITUTION OF THE MOON.—It is scarcely possible," says Dr. Nichol, "to conceive a more remarkable contrast than that between the appearance of the moon to the naked eye, and that which she presents to the telescope. Instead of a plain and bright surface, sending from all its parts an illumination not far from equable, we discern a body of most strange character, broken by irregularities which, in extent and form, present few analogies with the mountainous regions of our own globe. The reality of these, as well as the singularity of their contours, the briefest glance at the crescent luminary is sufficient to establish. The incomplete edge is, in that case, under the influence of a morning or evening light; and all the phenomena of lightened peaks, dark valleys, and long shadows, which occur in a broken district of the earth in such circumstances, are there distinctly visible, but on a scale far more grand. See, as example, plate VIII., which endeavours to represent the stupendous Appennines near the horizon, casting their black shadows on the plains of the *Mare Imbrium*. Look next at plate IX., a scene near

Tycho, where the sun is shining obliquely on the rims of tremendous pits, or circular caverns, some of which are as deep as Mont Blanc is high, and say if that beauteous luminary, notwithstanding her placid smile, has not, even as our own shattered globe, undergone a troublous history!

"It will be seen, even from these two illustrations, that a more complete survey of the moon's surface is quite within our reach. No elevation of any magnitude, when on the edge, can fail to cast a long shadow, the rays of the rising or setting sun then falling on it very *obliquely*; and not only does this shadow reveal the *existence* of the elevation, but its length, which can be accurately measured, must evidently indicate the *height* of the mountain or ridge.

"Acting on these simple principles, and therefore watching the crescent edge through many lunations, several celebrated astronomers have constructed maps of our satellite. The map on the opposite page gives a correct general notion of the moon's surface. The comparatively unbroken and regular portions occupy not more than one-third of the entire disc.

"Concerning these, I shall make only one remark as a necessary preliminary.

"Although the ancient nomenclature, in which they are designated the 'sea of serenity,' 'the sea of showers,' 'the sea of storms,' &c., has been continued to avoid inconvenience, no doubt remains on the question as to what they are. They are large flats or plains, forming, perhaps, the normal surface or level of the moon; but they, too, are variegated by irregularities, although comparatively slight ones; and certainly they contain neither seas nor lakes. Is it not a strange thought at the onset, that our companion luminary, that which of all is nearest us, should be thus widely apart, so different in a fundamental character from the earth? As the disturbed district of the moon covers at least two-thirds of the entire disc, it is to the nature of these rugged and extraordinary elevations that I shall first request attention, leaving the plains for after discussion.

"Taking the lunar mountain formations in the order of their simplicity, we discern, at the onset, a great number of perfectly isolated peaks, or sugar-loaf mountains, *unconnected with any group or range whatsoever*. These singular formations in the moon, however, very often present no analogy in this respect, with the corresponding phenomena of our planet. They rise suddenly from the midst of unbroken flats, and at a great distance from general dis-

turbances. They seem to have shot through the plain, in obedience to some sharp internal force, as one would push a needle through a sheet of paper; and the plain has not been much more disturbed.

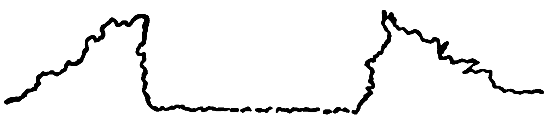
" Perhaps the finest instance of this is *Pico*, a very brilliant rock, about half as high as the loftiest of our Alps, which towers almost precipitously north of *Plato* (No. iii. in the map). No system whatever is connected with that remarkable peak; it is there a solitary, unaccompanied protrusion.

" As we proceed, however, greater apparent breaches of analogy will press for notice; although, if I mistake not, by their very contrariety with what surrounds us, these will, in some instances, throw light on problems regarding the structure of our globe which have hitherto baffled inquirers.

" Mountain ranges or chains are by no means wanting in the moon; although a glance at the map will show that they are not a chief feature among the elevations of that body.

" Their general position is a sort of circular but broken skirt of the greater flats or plains. There are two sets of phenomena connected with these lunar ranges bearing so closely on some theories regarding similar terrestrial forms, that I am induced to specify them.

"We find, as on the earth, that the ridge is uniformly extremely steep on one side, descending to the plain through abrupt terraces, while they slope away, as ours do also, on the other side, through an extensive and gently declining highland. The Lunar Appennines (plate VIII.) and the Asiatic Himalaya are illustrations of this singular fact, of about equal force. But the moon unfolds something more: the abrupt face of the mountain chain is uniformly *towards the plain*, the plain, for instance, is always engirdled in this fashion,



never as below:

"This is very distinct in the case of the *Mare Imbrium;* and we find the same with regard to every other plain, such as the *Mare Serenitalis* (VII. on the map). Turn now to the earth. Suppose the vast Pacific drained of its water, and that the Indian and Southern Oceans had become dry land; that would be a mighty flat or low land, broken only as the lunar plains are broken—here and there by a ridge, a crater, and a group of mountains; but observe its edge! Skirted on one side by the precipitous faces of the Andes and Rocky Mountains, and on the other, after some breaks, by the still more precipitous Himalaya and the Paropamisan, and then by the fronts of the heights of Abyssinia and Lupata—in all of which the slope is on the *opposite side,* forming in the two chief instances, the continent of South America and the long inclination of Siberia. This is not a mere *analogy* but an *identity* of phenomena. And their solution must, in both orbs, be connected with the formation of the plains which these precipices engirdle. It has yet to be found; but our terrestrial geographer may, in the meantime, safely dismiss speculations concerning floods and vast currents as being the cause of the contrast of these opposite contours, seeing that he must comprehend the moon also, where there is no water, and never has been!

"It will be granted me, that when a terrestrial phenomenon is sought to be referred to some cosmical agency, that is, to an agency not dependant on any *peculiarity* of the earth, but inherent in its nature *as a planet,* it is wholly legitimate to test the truth of the theory by applying it to the constitution of other orbs. Now, until very lately, it was scarcely possible to scan a few pages of a geological work without encountering cosmical theories regarding the elevation of our mountain chains. I shall refer to only one. The ingenious and learned De Beaumont proposed, not many years ago, what he termed the theory of secular refrigeration. It was in substance this:—The earth is still cooling; in the process of cooling the outer crust contracts; and, in the course of ages, it will press so violently on the molten mass within, that through the resistance of that mass it must *crack;* and the fragments will, by the protrusion of the internal fluid, be pressed upwards, and form mighty ranges of mountains. It followed from this theory, that all the ranges would, in the main, lie along great circles of the sphere; and De Beaumont superadded the assertion, that there would be other *parallel* cracks at the same time; so that all parallel ridges of mountains might safely be assumed to be of the same age, or to belong to the same epoch. How utterly the whole fair speculation

vanishes before one glance into the universe farther than our own door steps! If the earth was cracked in this wise, so must the moon have been; but in the moon there is not one instance of a chain lying along a great circle of the sphere, or having connexion with aught save the great plains; and there are no parallel ridges at all! Ply the hammer, O geologist! Continue to ply it well, but sometimes also look through the telescope! A theory of mountain elevations lately brought forward by Sir John Herschel and Mr. Babbage, appears liable to an objection directly opposite to that under which De Beaumont falls—they have sought to explain a cosmical fact by a theory founded on the specialities of the earth. How can the doctrine of abrasion, &c., be made applicable to the moon?

"But I must hasten on. I have now reached the most wonderful portion of the moon's mountain districts, a portion with which we have here nothing beyond the faintest similitude. At least three-fifths of the surface of that luminary are studded with caverns penetrating its body, and generally engirt at the top by a great wall of rock, which is serrated and often crowned by lofty peaks. . . . . On the opposite page is an ideal sketch, by my friend, Major Davis, which embodies most of their peculiarities, and will greatly aid my reader, as he goes with me where I now propose to take him—on a visit to the crater Tycho.

"Ascend, then, O traveller! averting your eyes from the burning sun; and having gained the summit, examine the landscape beyond! Landscape! It is a type for the most horrible dream—a thing to be thought of only with a shudder. We are on the top of a circular precipice, which seems to have enclosed a space of fifty-five miles in diameter from all the living world for ever and ever! Below, where the wall casts its shadow, it is as black as Orcus—no eye can penetrate its utter gloom; but where daylight has touched the base of the chasm, its character is disclosed, ... an unbroken precipice 13,000 feet deep, below which a few terraces alone disturb the uniformity; and at its base a chasm, deeper by 2,000 feet than Mont Blanc is elevated above the level of the sea! It is, indeed, a terrible place! There are mountains in it, especially a central one 4,000 feet high, and five or six concentric ridges of nearly the same height, encircling the chasm; but the eye can rest on nothing except that impassable wall without breach, only with a few pinnacles on its top, towering 17,000 feet aloft on every side, at the short distance of 27 miles, and baffling every attempt to escape into the

outer world. Nothing here but the scorching sun and burning sky; no rain ever refreshes it, no cloud ever shelters it; only benign night with its stars, and the mild face of the earth. But we tarry here no longer. . . . . . Look around now from the top of that highest pinnacle and away from *Tycho*—what a scene! Those round hills with flat tops are craters, and the whole visible surface is studded with them, all of less diameter than Tycho, but probably as deep. . . . . . What conception can we form of chasms so tremendous? Can there be life in them, or are they by some primeval cause shut out, like the Dead Sea, from all other realms of the ETERNAL? . . . . .

"Passing from Tycho, we cross some millions of centuries (!) and reach the epoch of gradual operation.

"The rays of the pearly COPERNICUS exhibit that magnificent crater in entire contrast with the spasmodic formation I have described. Instead of branching over a large portion of the moon, these rays are confined to a comparatively small space—an irregular patch of light—which is easily seen with an ordinary telescope; and even there they do not appear to have disturbed, to an appreciable extent, the previous surface, far less the crust of that luminary. . . . . . When I look at Copernicus, I am constrained to revert to our own Etna. If, in our best map of Etna, the stréams of lava were multiplied a thousand-fold, *that* would be the aspect of Copernicus. . . . . .

"Although the rays from Copernicus stretch to a great distance, there is nowhere any interruption to their perfect visibility. . . . . . There is not the slightest trace of obliteration from debris, or of concealment by foliage in those parts of the moon. The rocky rays from Tycho form the clearest part of the face of the luminary, undisturbed by meteorological action, and unadorned, there, at least, even by a shrub or a lichen. They seem, like many a granitic precipice amongst the Alpine regions of our own globe, dissevered from connexion with organic things, resting *bare* under the broad eye of heaven.

"The rays from Copernicus *interfere* with those which proceed from two other brilliant craters in its neighbourhood. Let us see the meaning of this interference. What is indicated by such a fact in our terrestrial geology? If a ray or vein from one granite mass cuts the vein from another granite, we instantly infer the *posteriority of the former*. Now, I find that rays from Kepler cut through rays from

Copernicus and Aristarchus, while rays from this latter cut through rays from Copernicus. There is, therefore, no doubt whatever as to the relative ages of these interfering streams. They stand in this order—Copernicus, Aristarchus, Kepler. The question simply remains, whether these interfering rays are fundamental ones, or the result of successive eruptions. . . . . . The time, I believe, has come, when, on rational and not mere cosmogonic considerations, we may divide the formation of that orb according to their great epochs, as we have already separated the modern structure of our own globe, and thus we shall learn the history of the throbs and throes through which she has passed. And if this is so, the moon must enter among our physical sciences as a phenomenon probably to modify them all; she must show, under new conditions, the action of forces, the annals of whose workings on our own planet are only second in sublimity to the solemn mutations of the heavens.

" Quitting the rugged or mountainous district of the moon, we turn to the low flats or plains, where, too, are materials for curious thought. . . . . . They are not absolute flats, but low grounds, through which low ridges pass, in the midst of which isolated peaks sometimes arise, and where craters, wide and narrow, but not of great depth, may be found. They are, in the meantime, *the undisturbed part of the moon's surface.*

" They are distinguished by a very great variety of colouring. . . . . . The most gorgeous exhibition of it is in the brilliant, but, I fear, wholly unrepresentable *greens* of the *Mare Serenitatis*. But what means that colouring? . . . . . can it be foliage? If organization exists in that strange globe, it is clear that we must reach the knowledge of it first through its forests and savannahs. There is another fine illustration in the patch near Aristarchus, which seems almost a picture of the varied colouring of a beautiful undulating country. And yet how strange this conception appears! a world with vegetation without water, and with so small an atmosphere! Stranger, still, if that globe has no communion with organized things; if LIFE, which, by its mighty assimilative energies, has so bent under its dominion the rocks of our own world, should be powerless in that globe, even under those hard conditions. It surely cannot! The moon, as I write, hangs over Goatfell's silent peak, and the stars are out without a cloud. And as, with a longing heart, I yearn towards the mystic Infinite, the faces of the loved and the lost, with the long-missed looks of home, seem bursting through

the sky, speaking of the peace of primal times, and of the wide, wide government of God."*

While we would adduce the moon as another, and very striking instance of a supposed objection resolving itself into an additional confirmatory evidence, we would remind our readers, that the subtile expansive influence, whose origin and nature at the *first* we are endeavouring to investigate, was destined to perform other stupendous works on the *second* and the *third* days of the Mosaic week—works of such a character that inconceivable volumes of the expansive principle must have been and were permanently employed in producing them. Fixed by the Creator's powerful and unerring hand, the same element sustains, to this hour, the firmament like a spread-out curtain over our heads; causes the watery vapour to arise and expand throughout its aerial extent; sustains and invigorates the whole of the vegetable kingdom, which, by its impartation, rose in such beneficial and attractive forms above the level of the earthy soil, and still spread forth their beautiful towering stems and shady branches in testimony of his power and faithfulness, and his benignity to his creatures. Those works, of wondrous extent, were quite sufficient, of themselves, to have expended the electro-magnetic force, which was put into energy on the *second* and *third* days, even had we not additional evidence, in the law previously referred to, of a uniform motion being the result of a continued application of the magnetic current; while a faint conception of the amazing amount of electrical fluid which must have been employed, in producing and perfecting these world-wide works, may be obtained by the knowledge of the fact, that, by repeated and well-attested experiments, Dr. Faraday has shown, "that the quantity of electricity holding the elements of a single grain of water in chemical combination would, if discharged under the form of a current, through a wire of platinum, about the 1-104th part of an inch in diameter, keep it red hot in the air for nearly four minutes."†

* Contemplations of the Solar System, by Dr. Nichol, third edition, pp. 141—168.

† Experimental Researches in Electricity, p. 250.

In further confirmation of this particular part of our subject, and in order to accumulate every possible evidence, we bring forward the relative direction of the moon's axis, when compared with that of the earth, as another modicum of evidence which may be turned to account.

Although the plane of the moon's orbit be inclined 5° 8′ 48″ to that of the earth, nevertheless, the axis of the satellite being almost perpendicular to the plane of its own orbit, shows that the single movement, whereby it performs a double motion in space, is the same now as when first created; that it still retains the identical position which it did when circulating around the earth and its own axis, ages before it was shone upon by the rays of that sun around which it accompanied its primary, in comparative unusefulness. The Dynamical Theory of the earth's formation—based with implicit confidence on the announcements of Scripture—opens up to the imagination, in the clearest manner, some retrospective views of the wonders of Creation, and the events which were taking place in the material universe, long before there was an eye to behold, or a pen to record them. We feel, moreover, sincerely persuaded, that when brought under the notice of minds thoroughly trained by those scientific researches to which they have reference, it will be the means of unfolding to the world's inhabitants, conceptions so vast of the infinite wisdom and goodness of the Creator, as shall constrain even the coldest, most obdurate heart, and the most averted inclination to honour and to glorify him, by giving entire credence to his Word as the only true means of attaining a thorough knowledge of his works.

There is another point to which it would be well if we could direct the reader's attention; but we feel we are not possessed of the requisite astronomical knowledge to do so properly. We allude to the bounds within which we are shut up for determining the *direction* in which the force, causing diurnal rotation, came into contact with those spheres put into motion by it; inasmuch as the axes of rotatory motion bear some degree of parallelism to those of orbital motion, which existed for ages before the latter movement was introduced into the material universe; certainly before it was experienced within

the confines of the solar system. During the whole of that period, although the earth itself had no diurnal motion, the hollow sphere of water which surrounded our globe described a circle of rotation round an axis, in consequence of the attractive influence of the sun and moon disturbing the perfect level, to which a liquid, hollow sphere, resting on a uniformly level, solid base, would, otherwise, have assumed, and have continued to observe—a datum which is worthy of consideration. In the individual case of our planet, this deduction is brought still closer home, from the fact that the axis of rotatory motion are not very wide apart from those of the moon's path around its primary, the former moving in a plane of a little more than five degrees of obliquity from that of the ecliptic.

It is scarcely possible, with any degree of certainty, to demonstrate the course observed by the primary light when it was made the instrument of causing the rotation of our globe. In conjunction with forces which had been previously willed into existence it certainly *did* occasion that important event in the earth's history. This we are led clearly to infer from revelation; and are confirmed in the same opinion by close deductions from scientific facts; these separate branches of evidence combining to show us, assuredly, *that at the period in question, and while circumstanced as we have supposed the sphere to have been, it performed its protorotation.* But to give a strict demonstration of how the mighty operation was wrought out is beyond our capability to accomplish.

We can produce no miniature sphere encoated, layer above layer, with electric generating materials of brittle mould, surrounded by a zone of acidulated water, and freely poised in mid-air ready to revolve; and then, by applying the voltaic current to exhibit its rotation, the breaking up of its concentric crust; the rising of its tiny continents, and the thrusting up of its inimitative mountain peaks, the depression of its miniature ocean hollows, and the rush of its mimic oceans from the poles to the equator. But so surely as all these manifestations of protorotation exist in real grandeur on the surface of the earth we tread on, and that they can be seen, touched, examined, and commented upon, so sure are we, that there was

power enough in the primary light, virtue enough in the concentric strata and ancient ocean, and time enough of darkened circuit through the etherless heavens (whereby the non-rotating sphere may have become sufficiently electrified) to cause the earth to arise from its slumber of ages and to perform its first diurnal revolution—and thereby occasioning the magnificent diversity of appearance which its expanded surface now happily presents. And moreover, although dim in the distance, yet we think we can penetrate far enough into those wonderful arcanæ of creation to perceive traces, faint, indeed, but true outlines, of the working of the secondary forces which were made the instruments of this first revolution of our pedestal around one of its diameters, which had previously held no pre-eminence over any of the others.

We can recognize clearly, that between two justly equipoised forces it was sustained in space, made to revolve around the centre of gravity of the system, and held perfectly free to rotate whenever diurnal motion should be expedient. We have made out, completely to our own satisfaction, and we trust to that also of our readers, that the LIGHT, or expansive principle, had not the sun for its centre during the first three days of its existence; and this of itself, is going a great way towards solving the problem, because the solar centre is that alone from whence an emanation of the expansive principle could *not* have caused rotation. This and the attractive influence would, in that case, have travelled in parallel lines and opposing directions, and therefore could not by their conjoint influence have produced a *tangential* result; but not being in or around the sun, *any other centre whatever* must have produced an oblique direction, lesser or greater according to the angle, and consequently an oblique impulse upon the one previously established, namely, Gravity—which passed then as now through the sun—the light not having been resident where it now is; it may be assumed to have been *anywhere* else. We are at liberty to suppose, that the motion which was given to the primary light, or the ethereal fluid, when it was divided from the darkness, was in any direction relative to darkness or attraction, which was most conducive to the objects then to be wrought out by its impulse. Its residence around the sun

having no indispensable or necessary connexion with *light*, any further than its being *now* there is conducive to the welfare of myriads of beings, whose adapted construction would render them incapable of existence without it were so; yet, before it pleased the Omnipotent to concentrate light in that part of our system, the sun had not only no inherent relation to the subtile influence whose first effects we are now endeavouring to demonstrate; but was, of all other bodies, the least likely to become the centre of the direction of expansion; and whose primary impulse (which we are quite sure came *not* from the sun) we are thus at liberty, as we before reasoned out, to consider to have been that which is most consistent with perfect *Wisdom*, combined with almighty *Power;* directed by that eternal *Goodness* and *Justice* which induce the respecting and preserving of every previously promulgated law, and revealed, in the course of time, by that unerring *truth*, which could alone send forth a faithful narrative of what occurred, when it pleased the Almighty to make known to his sentient creatures what he had performed long before they were willed into existence.

From what has been said, therefore, we are induced to conclude, that the peculiar construction and mineral character of the stratified materials of the ancient earth were designed, amongst other purposes, to serve as a galvanic girdle of universal extent, and that the circumfluent ocean was intended to be a general receptacle for the acidulated fluid so indispensable in all electro-magnetic operations; that, being thus predisposed, by the wise forethought of the Creator, and having, by induction, accumulated sufficient electricity during its protracted revolution through the unillumined heavens,* the expansive influence, emanating from the newly-formed light, was made to impinge upon our system in a direction somewhat perpendicular to the plane of the ecliptic, or parallel to the axis of rotation of each planet, and by its tangential influence made to produce, in them, rotation at right angles to the direction in which it travelled through space, in a manner similar

* An iron ball was found to have acquired indirect electricity by circulating round another electrified body.

to that in which *electro-magnetism* affects objects of its affinity; and occasions rotation where the axis is fixed and the body free to revolve.

Every other direction in which the impelling force could have impinged upon the earth, so as to have overcome the inertia of a world diurnally at rest, has been shown to be objectionable; any one of them would have disturbed the perfect equipoise of the countervailing forces required to restrain the earth in its orbital path; and which confer upon it an axis round which it can with freedom revolve; *the line of the direction of the sun's rays, as they travel at present, being the most objectionable of all the others.* To these evidences— which are the legitimate deductions of scientific research— we have merely to add the concurring testimony, amounting to proof presumptive, which can be drawn from the announcements of Scripture, and which, when adopted without bias, leave not a doubt upon the mind, that, on the fourth day of the Mosaic week, the LIGHT was concentrated, by the command of God, around the central orb of our system; and, shedding its rays from thence upon our attendant luminary, it caused a lesser degree of light to shine, by reflection, upon us, when, by diurnal rotation, the direct rays of the sun were hidden from our view. In that portion of Scripture we are informed, as distinctly as language is capable of implying, that, on the fourth day of the Mosaic week, the light was concentrated around the sun, and thereby made to enlighten the moon, so that she should shed on us a lesser light; and, consequently, the very fact that this was performed on the *fourth* day, proves beyond the possibility of a doubt, that the primary light did not encircle that luminary during the *first three days* of its existence. And if it did not—which we have clearly demonstrated by proof both from science and from Scripture— then it may as well be considered *to have been situated, as we have supposed, in accordance with what electro-magnetism may hereafter demand on further investigation;* or, in other words, *in that state which is most accordant with the effects which have flowed from it.*

Notwithstanding the apparent conclusiveness of the evidences which we have brought forward from so many converg-

ing sources, it may still be attempted to be denied that the protorotation of the earth commenced at an epoch so late in the history of its existence as that which the Dynamical Theory assumes, and requires for it complete establishment; and, probably, the bygone error of supposing, that rotatory motion was impressed upon the earth by the same primary projectile impulse by which it was translated in space, may be attempted to be upheld in opposition. Fortunately, however, the fulcrum on which our main argument turns is too secure, and too tangible to the senses to be so easily set aside. Every scarped peak of primary granite, which has displaced the once superincumbent stratiform masses, and towers its head above them, enveloped by the fleeting clouds around, affords the surest proof of the faithfulness of our assertions ; for, as durable and undeniable as are those elevated masses of solid rock, so indestructible are the proofs which we deduce from them; and so transient as are the passing clouds which may, for a moment, obscure them from our view, so evanescent must be every attempt to deny that their elevation was caused by the first rotation of the earth around its axis, ages after it had been willed into existence, and when sufficient time had been afforded for the once superincumbent strata to settle down in concentric superposition, and to arrange themselves into those levers which were afterwards to contribute so essentially to the overcoming of the earth's inertia, and to the upheaving of its continental ridges! So different from our ways and our conceptions are those of the Omniscient and Omnipotent Creator!

As long as one solitary peak of granite o'ertops the mountain brow to vouch for the truth of the Dynamical Theory, so long may we point to it with perfect confidence, and exclaim—"Behold the best and the most irrefragible proof of the truth of the announcements of Scripture; and the wisdom of referring to them, and of carrying them along with us in all our endeavours to unravel the arcanæ of nature!"

Before taking leave of this interesting part of our subject we may observe, that the whole tenor of our discourse completely puts an end to all fanciful or figurative conceptions which have been applied to the *duration of the day*, so frequently mentioned in this portion of scripture.

The Dynamical Theory maintains, that it was a *natural day of twenty-four hours*, and requires, for its completion, the centrifugal impetus arising from the rotatory motion of 15° per hour, which the limitation of the above period, within natural bounds, can alone supply; and it besides requires, that this force should have been put forth simultaneously with the introduction of the light, or rather, that it should have been the cause of the upheaving of the continents and mountains, and the depression of the oceanic hollows, &c., as stated. For if the day were supposed to have been longer than twenty-four hours, we shall be altogether deficient in dynamical power to which to attribute the numerous inequalities of the earth's surface; while, on the other hand, if it be presumed that these geographical features have existed ever since the sphere was translated in space, besides the difficulty of accounting for their origin, we should have the dynamical power of rotation, at the rate of 15° per hour, too much, by having no adequate objects on which to show that it was expended. This theory brings all those data to be at one, and perfectly reconciles them. By assuming the protorotation of the earth to have taken place, as in reality it did, on the first day of the Mosaic week, by considering the specified period "of evening and morning," to have been a natural day, measured by a revolution of the earth around its axis, and by attributing the change of form which it underwent, and the diversified appearance of its surface to the force which this rapid diurnal movement, instantaneously communicated, necessarily produced, we are relieved from all perplexity of mind, and made to see the whole to be parts of one grand and comprehensive plan: *the work of creation, carried on through innumerable ages, but completed in six natural days.*

SECTION IX.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XXXIX.

Introductory observations. Mosaic record respecting the concentration of the primary light. The same subject treated scientifically. The earth a non-luminous body, receiving its external light and heat from the sun. Considerations which result from this fact. Constitution of the solar light enquired into by a consecutive series of investigations. Polarization of light: sun's rays not possessing this remarkable property. Therefore not proceeding from an encandescent body, but from a luminiferous atmosphere. The same argument followed up by another approach. Identity of Electricity and Light, and of the various kinds of electricity with one another. Intimacy subsisting between Electricity and Magnetism. Terrestrial magnetism. Scientific investigations respecting the origin of these recondite magnetic currents. And, in conclusion of this chapter, evidences to prove that Light, Heat, Electricity, and Magnetism, are considered to be diversified manifestations of the same comprehensive law of nature.

In the Record of our Faith we find it narrated, that after all the wondrous works had been performed by the instrumentality of the primary light, which are mentioned in the transactions of the first three days of the Mosaic week, and whilst that subtile agency was in a different state from what it now is, and before it was concentrated around the sun—

"God said," on the fourth day, "let there be lights (or luminaries) in the firmament of the heaven, to divide the day from the night; and let them be for signs, and for seasons, and for days, and for years: and let them be for lights in the firmament of heaven, to give light upon the earth: and it was so. And God made two great

lights; the greater light to rule the day, and the lesser light to rule the night: *he made* the stars also. AND GOD SET THEM IN THE FIRMAMENT OF THE HEAVEN, to give light upon the earth, and to rule over the day and over the night, and to divide the light from the darkness: and God saw that it *was* good. And the evening and the morning were the fourth day."*

Such is the important passage which, while it accounts for this wonderful operation, is remarkable for the characteristic and convincing simplicity of the words in which it is couched. Language which, alone, could be employed by the Omnipotent, when he graciously condescends to inform us of the expressions of his volition, in willing that the primary light should remain permanently in the centre of our system; and what a God-like labour it was, to cause that which, by its characteristic tendency, *propends towards the circumference, to concentrate itself, at his bidding, around the central orb of our system,* and there to remain fixed and immovable to fulfil his future designs! Who but God could do this? And when the simplicity of the words is contrasted with the magnitude of the work, can it be any longer doubted that it is God also who speaks? To our mind, the very simplicity and conciseness of the language employed carries a conviction which nothing can weaken or destroy; for, who but the Almighty has a right, or could express himself thus of such a work? And it is, moreover, well worthy of observation, that by Jehovah they were set in the firmament to give light upon the earth; this being, in reality, the circumscribed duty which the sun's rays daily perform, whatever may be the sign or the season.

But let us endeavour to corroborate this latter view of the case by such declarations of science as have reference to it.

The first point to which we have to direct the attention is, to the fact of "the earth being, of itself, a non-luminous body, receiving its external light and heat from the sun;"† and, then, to the following considerations which arise from it; that there are only *two* ways in which the earth could, at this particular period, have been caused to receive light and heat from another orb around which it circulates. Firstly. The simultaneous

* Genesis i. 14—19.

† *Second* Theorem.

formation of the material body of the sun, *with its luminiferous powers;* and its being placed, thus doubly constituted, into the centre alike of attraction and of expansion; and by causing the earth to revolve in its orbital path around it. Or, Secondly. By supposing the material part of the sun to have been *previously* in existence, although *not illuminated,* the earth revolving around it by the same laws which now cause it to do so; and that while in this state, the light was made to concentrate around the previously dark nucleus as a *luminiferous atmosphere,* dispensing rays from every point of its equatorial circumference, on its being set in "the firmament of heaven."

Against the *first* of these suppositions there are very many and insuperable objections. It is quite inconsistent, with what we know of the laws of matter, to conceive the existence of the earth, not only for three days, but for as many moments, without presupposing the existence, likewise, of the other planets, and the *material body of the sun,* as counterpoises to one another, in the mutual system of which the earth forms only one member. Again, it is impossible to imagine the existence of matter without attraction, or attraction in the solar system without revolution in appointed orbits through space; for without this last counterpoise to attraction the material universe would have gravitated into one vast and boundless whole—a universe of undivided matter! But if we must suppose revolution in space, then there must needs have been a central mass round which, and the common centre of gravity, the revolution was to be performed by the revolving bodies; while, in addition to all other objections, there can be adduced the words of the command itself—"Let there be lights *in the firmament* of heaven:" for who, after having been made acquainted with the nature and constitution of the firmament, could, for a moment, suppose this to apply to the *material* bodies of the sun and moon, or imagine that it was ever meant that the firmament should be capable of upholding them, on the *fourth* day, in addition to those already in our system? Not so with respect to the latter of the two suppositions formerly mentioned; for then every conclusion is as con-

sistently favourable to it as they are adverse to the former. According to the natural interpretation, or strict signification of the Mosaic narrative, there was only one addition made to the laws which had been previously established. It was, *that there should be* LIGHTS, a *primary* and a *secondary* light, introduced *into the firmament of heaven;* and which by the mere act of being "*set there,*" were to become, to the earth, "signs, seasons, days, and years." In this command no mention is made of causing the one sphere to revolve around the other; or of forming the solid materials of those luminaries which were to produce these effects; but the command is *strictly confined to the lights themselves,* one of which was to be *greater* than the other, and they were to be "set in the firmament of heaven," which, from our knowledge of the *earthly* firmament, we presume alludes to *the firmament of the sun.*

Now, if we meditate upon this passage, under the consciousness of the earth having for ages revolved around the unilluminated solid nucleus of the sun; and which, we trust, we have elsewhere obviously shown was the condition of our planet, we shall immediately recognize the peculiar harmony of this command with, not only all the laws formerly instituted, but likewise the original structure of the materials of the earth itself; while no difficulty will ever afterwards be experienced in fully comprehending this otherwise inexplicable passage of scripture: besides, it will be found to agree most admirably with those views at present entertained, and considered to be the most scientific as to the *nature* and *constitution* of the *solar atmosphere.* To verify this, while we may be allowed, for the unity of our argument, to disregard as irrelevant to our present enquiry, the merits of the contending theories respecting the intimate nature of light;* we shall follow up a branch of natural phenomena connected more directly with the luminiferous atmosphere which is supposed to surround the sun; and we begin by consulting the *second* part of the *thirty-ninth* Theorem:—"*That a pencil of light, by the*

* We need not, however, we presume, after what we have written, save our own opinion on this point.—AUTHOR.

skilful application of certain refracting and absorbing media, can be polarized or separated into two distinct pencils; one whose pole is $+ 45°$ *and the other having its pole* $- 45°$.

This interesting announcement being essential to our future argument, we shall give some of the evidences on which it is founded.

Mrs. Somerville bears the following testimony:—

"In 1808, while M. Malus was viewing, with a doubly refracting prism, a brilliant sunset reflected from the windows of the Luxembourg palace, in Paris, on turning the prism slowly round, he was surprised to see a very great difference in the intensity of the two images, the most refracted alternately changing from brightness to obscurity at each quadrant of revolution. A phenomenon so unlooked for induced him to investigate its cause, whence sprung one of the most elegant and refined branches of physical optics. . . . .

"In giving a sketch of the constitution of light," she observes at another place "it is impossible to omit the extraordinary property of its polarization. . . . . .

"Light is said to be polarized, which, by being once reflected or refracted, is rendered incapable of being again reflected or refracted at certain angles. . . . . .

"If a ray of light be reflected from a pane of plate glass at an angle of 57° it is rendered totally incapable of reflection at the surface of another pane of glass, in certain definite positions, but it will be completely reflected by a second pane in other positions. It likewise loses the property of penetrating transparent bodies in particular positions, whilst it is freely transmitted by them in others. Light so modified as to be incapable of reflection and transmission in certain directions is said to be polarized. This name was originally adopted from an imaginary analogy in the arrangement of the particles of light, on the corpuscular doctrine, to the poles of a magnet, and is still retained in the undulatory theory. Light may be polarized by reflection from any polished surface, and the same property is also imparted by refraction. . . . . . All reflecting surfaces are capable of polarizing light, but the angle of incidence at which it is completely polarized is different in each substance. . . . . . The angles at which different substances polarize light are determined by a very simple and elegant law, discovered by Sir David Brewster: 'that the tangent of the polarizing angle for any medium is equal to the sine of the angle of incidence, divided by

the sine of the angle of refraction of that medium ;' whence also the refractive power even of an opaque body is known, when its polarizing angle has been determined. . . . . .

"The motion of the ethereal medium in elliptical and circular polarization may be represented by the analogy of a stretched cord; for, if the extremity of such a cord be agitated at equal and regular intervals by a vibratory motion entirely confined to one plane, the cord will be thrown into an undulating curve lying wholly in that plane. If to this motion there be superadded another similar and equal, but perpendicular to the first, the cord will assume the form of an elliptical helix, its extremity will describe an ellipse, and every molecule throughout its length will successively do the same. But if the second system of vibrations commence exactly a quarter of an undulation later than the first, the cord will take the form of a circular helix, or corkscrew; the extremity will move uniformly in a circle, and every molecule throughout the cord will do the same in succession." . . . . .

And, in conclusion, from this author—

"It appears, from what has been said, that the molecules of ether always perform their vibrations at right angles to the direction of the ray, but very differently in the various kinds of light. In natural light the vibrations are rectilinear, and in every plane. In ordinary polarized light they are rectilinear, but confined to one plane; in circular polarization the vibrations are circular; and in elliptical polarization, the molecules vibrate in ellipses.

"These vibrations are communicated from molecule to molecule in straight lines when they are rectilinear, in a circular helix when they are circular, and in an oval or elliptical helix when elliptical."*

Sir David Brewster gives the following evidence, which we ought, perhaps, to apologize for quoting so circumstantially, were it not unavoidable consistently with perspicuity:—

"A beam of solar light has the same properties on all its sides; and this is true, whether it is white light as directly emitted from the sun, or whether it is red light, or light of any other colour.

"The same property belongs to light emitted from a candle, or any burning or self-luminous body, and all such light is called *common* light. . . . . .

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* Connexion of the Sciences, pp. 219, 200—217.

"If we allow the same beam of light to fall upon a rhomb of Iceland spar, and examine the two circular beams *O o*, *E e*, formed by double refraction, we shall find—

"1. That the beams *O o*, *E e* have different properties on different sides, so that each of them differs, in this respect, from the beam of common light.

"2. That the beam *O o* differs from *E e* in nothing, excepting that the former has the same properties at the sides *A'* and *B'* that the latter has at the sides *C'* and *D'*; or, in general, that the diameters of the beam, at the extremities of which the beam has similar properties, are at right angles to each other, as *A' B'*, and *C' D'*.

"These two beams, *O o*, *E e*, are, therefore, said to be *polarized*, or to be beams of *polarized* light, because they have sides or poles of different properties; and planes passing through the lines *A B*, *C D*, or *A' B*,' *C' D'*, are said to be the *planes of polarization* of each beam, because they have the same property, and one which no other plane passing through the beam possesses.

"Now, it is a curious fact, that if we cause the two polarized beams *O o*, *E e*, to be united into one, or if we produce them by a thin plate of Iceland spar, which is not capable of separating them, we obtain a beam which has exactly the same properties as the beam *A B*, *C D*, of common light.

"Hence we infer, that a beam of common light, *A B*, *C D*, consists of two beams of polarized light, whose planes of polarization, or whose diameters of similar properties, are at right angles to one another, ... from which it follows, that there are three ways of converting a beam of common light, *A B*, *C D*, into a beam or beams of polarized light.

"1. We may separate the beam of common light, *A B*, *C D*, into its two component parts, *O o*, *E e*.

"2. We may turn round the planes of polarization *A B*, *C D*, till they coincide, or are parallel to each other; or,

"3. We may absorp or stop one of the beams and leave the other, which will, consequently, be in a state of polarization." . . . .

"It does not appear," he continues, "from the preceding experiments, that the polarization of the two pencils is the effect of any polarizing force resident in the Iceland spar, or of any change produced upon the light. The Iceland spar has merely separated the common light into its two elements, according to a different law, in the same manner as a prism separates all the seven colours of the spectrum from the compound white beam, by its power of refracting

these elementary colours in different degrees. The re-union of the two oppositely polarized pencils produces common light, in the same manner as the re-union of the seven colours produces white light."

Somewhat farther on, Sir David informs us that—

"In the year 1810, the celebrated French philosopher, M. Malus, while looking through a prism of calcareous spar at the light of the setting sun, reflected from the windows of the Luxembourg palace in Paris, was led to the curious discovery that a beam of light reflected from *glass* at an angle of 56°, or from *water* at an angle of 52° 45′ possessed the very same properties as one of the rays formed by a rhomb of calcareous spar; that is, that it was wholly polarized, having its plane of polarization coincident with or parallel to the plane of reflection.

"This most curious and important fact, which he found to be true when the light was reflected from all other transparent or opaque bodies, excepting metals, gave birth to all those discoveries which have, in our own day, rendered this branch of knowledge one of the most interesting, as well as one of the most perfect of the physical sciences."*

Sir John Herschel may be said to have summed up the evidence regarding these optical discoveries, when he favours us with the following account of their progress. We regret that the nature and limits of our work constrain us to give merely an abridgement, and would, therefore, recommend a perusal of the original:—

"After a long torpor," he observes, the knowledge of the properties of light began to make fresh progress about the end of the last century, advancing with an accelerated rapidity, which has continued unabated to the present time. The example was set by Dr. Wollaston, who re-examined and verified the law of double refraction in Iceland spar, announced by Huyghens. . . . . . The prosecution of the subject was encouraged by the offer of a prize on the part of the French Academy of Science: and it was in a memoir which received this honourable reward, in 1810, that M. Malus, a retired officer of engineers in the French army, announced the great dis-

* Optics, in Cab. Cyc. pp. 157, 163—165.

covery of the *polarization of light*, by ordinary reflection, at the surface of a transparent body. . . . . .

"This was the first circumstance which pointed out a connexion between that hitherto mysterious phenomenon and any of the ordinary modifications of light; and it ultimately proved the means of bringing the whole within the limits, if not of a complete explanation, at least of a highly plausible theoretical representation. . . . .

"The new class of phenomena thus disclosed were immediately studied with diligence and success, both abroad by Malus and Arago, and at home by Dr. Brewster, when another and, apparently, still more extraordinary class of phenomena presented itself in the production of the most vivid and beautiful colours. . . . . . The attentive examination of these colours speedily led to the disclosure of a series of optical phenomena so various, so brilliant, and evidently so closely connected with the most important points relating to the intimate structure of crystallized bodies, as to excite the the highest interest—that sort of interest which is raised when we feel we are on the eve of some extraordinary discovery. . . . . .

"This expectation was not disappointed. So long before the time we are treating of as the first year of the present century, the late Dr. Thomas Young . . . . . was led to the idea that the same ought to hold good with light as with sound, if the theory which makes light analogous to sound be the true one; and that, therefore, two rays of light, setting off from the same origin at the same instant, and arriving at the same place by different routes, ought to strengthen, or wholly or partially destroy each other's effects, according to the difference in length of the routes described by them.

"That two lights should, in any circumstances, combine to produce darkness, may be considered strange, but is *literally true*. . . . . . The experimental means by which Dr. Young confirmed this principle were as simple and satisfactory as the principle itself is beautiful; but the verification of it, drawn from the explanation it affords of phenomena apparently the most remote, are still more so. . . . . .

"Nothing now was wanting, indeed, to a rational theory of double refraction but to frame an hypothesis of some mode in which light might be conceived to be propagated through the elastic medium supposed to convey it in such a way as not to be contradictory to any of the facts, nor to the general laws of dynamics. This essential idea . . . . . was also furnished by Dr. Young, who, with a sagacity which would have done honour to Newton himself, had

declared, that, to accommodate the doctrine of Huyghens to the phenomena of polarized light, it is necessary to conceive the mode of propagation of a luminous impulse through the ether, differently from that of a sonorous one through the air. In the latter the particles of the air *advance* and *recede;* in the former those of the ether must be supposed to *tremble laterally*. . . . . .

"M. Freswell succeeded in erecting on this hypothesis a theory of polarization and double refraction so happy in its adaptation to facts, and in the coincidence with experience of results deduced from it by the most intricate analyses, that it is difficult to conceive it unfounded. . . . . . And so long as it serves to group together in one comprehensive point of view, a mass of facts, almost infinite in number and variety, to reason from one to another, and to establish analogies and relations between them, ... it can never be regarded as other than a most real and important accession to our knowledge. . . . . . Indeed the science of optics, in this respect, has rendered to mineralogy and crystallography services not less important than to astronomy by the invention of the telescope, or to natural history by that of the microscope; while the relations which have been discovered to exist between the optical properties of bodies and their crystalline forms, and even their chemical habitudes, have afforded numerous and beautiful instances of general laws concluded from laborious and pains-taking induction, and curiously exemplifying the simplicity of nature, as it emerges slowly from an entangled mass of particulars, in which, at first, neither order nor connexion can be traced."*

Having become acquainted with what is implied by the *polarization* of light, we must now learn the application intended to be made of it to our present argument. For this purpose let us refer to the *forty-second* Theorem, which states:—"*That some late and delicate experiments in optics having proved, that rays from the sun, even when transmitted obliquely, are not polarized, whereas those which emanate from encandescent bodies possess this remarkable property, it follows as a consequence, that solar light does not issue from an encandescent solid or fluid, but rather—as Herschel previously supposed—from an exterior film which is the source of*

* Discourse on Natural Philosophy, Cab. Cyc. pp. 257—264.

its light; and that the intensity of the sun's light diminishes from the centre to the circumference of the solar disc."

The following, which are the details, will no doubt be read with pleasure before we proceed to make the application:—

"The sun," observes Mrs. Somerville, "has a very dense atmosphere. What his body may be, it is impossible to conjecture; but he seems to be surrounded by a mottled ocean of flame, through which his dark, dark nucleus appears like black spots, often of enormous size. These spots are almost always comprized within a zone of the sun's surface, whose breadth, measured on a solar meridian, does not extend beyond 30½° on each side of his equator, though they have been seen at the distance of 39½°. From their extensive and rapid changes, there is every reason to suppose, that the exterior and encandescent part of the sun is gaseous. The solar rays probably arising from chemical processes that continually take place at his surface, or from electricity, are transmitted through space in all directions; but, notwithstanding the sun's magnitude, and the inconceivable heat which must exist at his surface, as the intensity both of his light and heat diminishes as the square of the distance increases, his kindly influence can hardly be felt at the boundaries of our system; or, at all events, it must be but feeble."*

"From the fact," observes Sir John Herschel, "that the most vivid flames disappear, and the most intensely ignited solids appear only as black spots on the disc of the sun when held between it and the eye, it follows, that the body of the sun, however dark it may appear when seen through its spots, *may*, nevertheless, be in a state of the most intense ignition. It does not, however, follow of necessity that it *must* be so. The contrary is at least physically possible. A *perfectly reflective* canopy would effectually defend it from the radiation of the luminous regions above its atmosphere, and no heat would be conducted downwards through a gaseous medium increasing rapidly in density. That the penumbral clouds are highly reflective, the fact of their visibility in such a situation can leave no doubt.

"The immense escape of heat by radiation, we may also remark, will fully explain the constant state of tumultuous agitation in which the fluids composing the visible surface are maintained, and the

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* Connexion of the Sciences, p. 254.

continual generation and filling in of *the pores*, without having recourse to internal causes. . . . . .

"The great mystery, however, is to conceive how so enormous a conflagration (if such it be) can be kept up. Every discovery in chemical science leaves us here completely at a loss, or rather, seems to remove further the prospect of probable explanation. If conjecture might be hazarded, we would look rather to the known possibility of an immediate generation of heat by friction, or to its excitement by the electric discharge, than to any actual combustion of ponderable fuel, whether solid or gaseous, for the origin of the solar radiation."*

"There is no obvious connection," observes Professor Whewell, "between mass and luminiferousness, or temperature. No one, probably, will contend that the materials of our system are necessarily luminous or hot. According to the conjectures of astronomers, the heat and light of the sun do not reside in its mass, but in a coating which lies on its surface."*

"It followed at once," Mr. Nichol asserts, "from Wilson's capital achievement, that our magnificent luminary is no chaotic conflagration, as had hitherto been supposed; and to the investigation of what it really is, the singular powers of the elder Herschel came quickly in aid of the efforts of his friend. With both of these illustrious men it seemed an unquestionable first impression, that the surface thus broken by chasms must be an elastic or gaseous fluid; for notwithstanding the magnitude of the spots, sometimes reaching even 50,000 miles in diameter, they open and close with a rapidity altogether marvellous, often surpassing the rate of a thousand miles a day. Granting, then, that this light-giving surface is some phosphorescent gas, what is the umbra and what the dark internal spaces? To these engrossing questions, Herschel, without delay, applied the energies of a mind that ever and anon was flashing into the unknown. It seemed to that penetrating genius, and no other theory will yet resolve the fact, that the sun consists mainly of a dark mass, like the body of the earth and other planetary globes, which is surrounded by two atmospheres of enormous depths, the one nearest to him being, like our own, cloudy and dense; while the loftier stratum consists of these dazzling phos-

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* Astronomy, Cab. Cyc., American edition, pp. 200—202.

† Bridgewater Treatise, p. 171.

phorescent zephyrs that bestow light and heat on so many surrounding spheres. In this view the following is the real meaning of a solar spot. By some unknown force from below, these atmospheres are disturbed and opened, the phosphorescent zephyrs being flung aside, we descry the dark clouds or shelving edges reflecting somewhat of the light beaming on them from above, which is the *umbra* below, the darker and more sombre, because more sheltered body of the great globe, as the central spot. Nor in all the annals of discovery is there aught that stirs thought or raises more strange questions than this !* Let us see into what it summons us to enquire.

"The play of sudden, tremendous, and evanescent forces, either connected with the solid body of the sun, or generated within his atmosphere, and made apparent by the surging and bursting of these atmospheres, has become an absolute fact. Now, whence and what are these ? But in the first place, and passing beyond the spots, let us briefly review the whole phenomena.

"There appears no rest whatever in the atmosphere of the sun. Over all its surface waves of light seem to dash incessantly, assuming the most varied aspects. The bright part, as Herschel early discerned, is full of inequalities ; showing, first, parts more brilliant than the rest, sometimes round, sometimes elongated, mountain billows of various forms in that light ocean. Then there are large darker spaces, extending over immense tracts, but showing no dark centres—these are Herschel's shallows. After these must rank the true spots or caverns, often surrounded by a ridge of intense light like the wall of a lunar crater. When such objects are examined *as a class*, we discern several circumstances too remarkable not to lie among the foundations of all rational theories concerning them. First. Though they have no relation to any individual point or points of the sun's surface, the same spot never re-appearing in the same place, nor indeed, *re-appearing at all*, they are yet closely related

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* The Mosaic account, however, is very simple and plain. Darkness and attraction are synonymes. The sun is and always was the centre of these influences. On the formation of the primary light, the sun (in common with the other orbs), was caused to rotate, and judging from analogy, had an atmosphere, commensurate to its own magnitude, conferred upon it. Subsequently, or, on the fourth day, "luminaries were set in the firmament of the heaven," which means that the remainder of the primary light was concentrated around the sun, and consequently around its proper atmosphere; and from thenceforward the darkest orb in the solar economy was made, by means of voltaic currents, to dispense light and heat to all the others of the system.—AUTHOR.

to a large *district*, for they are confined to a zone extending 40° on each side of the sun's equator, which may somehow connect them with the phenomenon of the rotation of that great orb. Secondly. They are not stable on the surface, but enjoy *proper motions*, apparently of a singular and strikingly symmetrical kind. They seem on each side of the equator to approach the nearest pole, and by paths wonderfully corresponding, at the rate, too, of two hundred miles an hour; so that, strange though it seem, even these chasms, so tremendous and evanescent, are bound together *as a system* by some grand law. Lastly. They present in many cases very extraordinary aspects when they are just disappearing. Most frequently, perhaps, a spot closes gradually, although with great rapidity, its lips, as I have seen them sometimes, approach at a rate of 40 miles an hour—what a tide must be there?—what a wave! It can be likened only to the force of the wind in one of our terrific hurricanes! Often the spot splits before it closes, light ridges darting across the central space, as if with the speed of lightning. The one vast chasm is thus resolved into many; and these have been known to separate from each other, and dart along in new and disturbed paths, in a manner not unfitly compared to the fragments of a cake of ice which has been thrown with violence upon the smooth surface of a frozen pool."*

These evidences, which all must consider perfectly impartial and given quite unconsciously as to the application which we have made of them, are very interesting; and when considered, more especially with reference to the opinions expressed in this theory, as to the existence of the *material* nucleus of the sun, of the earth, and of the other planetary bodies of our system, for ages previous to the formation of the light on the *first* day of the Mosaic week; together with the close conformity which the idea, of *a luminiferous atmosphere* around the sun, has to the spirit and the expressive words of scripture, all remaining doubts will assuredly be dispelled.

The announcements of the inspired historian apply much more obviously to the illumination of an atmosphere, than to that of a solid body—"Let there be lights (or, as in the marginal reading 'luminaries,') in the firmament of the heaven,"

* Contemplations on the Solar System, pp. 173—177.

are the words therein used; and when we reflect on what is meant by a "*firmament*," we conceive it almost impossible any longer to hesitate in admitting, that the views adopted by MM. Herschel, Wilson, Arago, Whewell, Nichol, and others, are correct; while the word "*let*," plainly points to the institution of a law which did not previously exist; and, consequently, to a modification, and thereby to an encroachment upon some one which had a prior existence; for the laws which governed matter, even before the formation of the light, must have been complete, and thoroughly consistent among themselves, and with the state in which every thing then was, it being impossible to conceive, that there ever could have been a void in the laws of the material universe! Besides, it is much more consistent with the conceptions we are led to entertain of the wisdom and goodness of the Omnipotent, to conceive, that a globe, like the sun, considered to be equal to 354,936 earths, should be fitted to be the abode of rational and animal existences; while, at the same time, it dispenses LIGHT and HEAT to all around it from its *luminiferous atmosphere,* which may be considered the deepest and densest of any of the whole system, than to suppose, that such an enormous mass of matter is maintained, in an encandescent state, merely to supply the planetary orbs with light and heat! Further, it ought not to be overlooked, that the inspired historian records the placing of those lights in the heavens *after* he had put on record the formation of our firmament; and there is nothing to lead us to imagine that what was taking place on the earth was not *simultaneously* taking place on the sun and other spheres of our system, the moon, perhaps, excepted. We have, therefore, in this remarkable coincidence of time, an additional evidence in favour of the position we have so resolutely assumed, and which we purpose, by every means in our power, to defend. Full conviction in favour of the assumption, will fall with greater force on the mind when it is considered, that the idea, on the other part, of *the sun being an encandescent mass of matter sending forth luminous rays,* although apparently in accordance with some of the more common phenomena exhibited by ignited bodies; so far from enabling us to explain the nature of the light and heat which

are communicated to us by that luminary, rather adds to the difficulty in a philosophical point of view; because, as has already been shown, so long as a single mass of granite is found perforating the stratified materials of the earth's crust, so long must it be admitted as a true and clear deduction therefrom, that unless the common centre of gravity of the solar system had been changed in the act of illuminating the sun, no additional matter causing gravitation could, with safety to the entire solar economy, have been added to that central body. LIGHT is the only thing known which possesses *no gravity*.* While, as the electrical influence residing in material bodies circulates at small appreciable depths beneath the surface,† it follows, that the rays would have possessed polarity had they proceeded in a certain direction from a material body encandescent itself by electrical agency.‡ But as they do not possess polarity, then they must reside, as supposed above, in the surrounding atmosphere, or, in other words, in the firmament of heaven, which, at the period mentioned in scripture, was caused to dispense luminous rays. And, in conclusion, the conception of an *ignited material mass* having been placed in the centre of our system on the fourth day of the Mosaic week, when applied to the other parts of the first chapter of Genesis, renders it wholly unintelligible.

Without any intention to detract, in the slightest degree, from the vastness and grandeur of our just conceptions of that Almighty power which could thus, at will, concentrate the newly created principle of expansion around the central orb of our system; and as assuredly around the focal orb of every other distinct system—and these conceptions will not be complete in their vastness, unless we consider that the principle alluded to, was, by its nature, disposed to expand—yet we cannot allow the present opportunity to pass without reverting, by connexion of ideas, to these interesting experiments in natural philosophy, already alluded to by us, during which, the non-luminous voltaic currents, which had been streaming unobserved by the eye along the conducting wires; and, at the will of the operator, caused to produce many won-

* Theorem 46. † Theorem 60. ‡ Theorem 42.

derful transformations and effects, are, of a sudden, brought together upon some interposed body, and made thereby to send forth the most intense rays of light and heat.* When it is considered, that whatever *now* occurs takes place because *it was then instituted,* that *it flows from laws then established,* are we wrong in imagining, that in this comparatively puny exhibition, shewing the diversified power of voltaic electricity, we do not behold a faint, faint indeed, yet kindred result to that which, when exhibited, on the *fourth* day of the Mosaic week, before the angels of God, made these heavenly spectators to "shout for joy?"

We may consider, that when the Omnipotent Creator of the universe had—by the application, in separate and divided streams of darkness, and of the newly-formed principle of expansion—brought into existence those successive changes which were considered necessary during the first three days of the Mosaic week, He bent the great stream of light in upon the central orb, and immediately its firmament or atmosphere became the radiating source of light and heat to all those planets, which before had hung upon it as the pivot of their dark orbital course through space; *and that, ever afterwards, the two great principles of attraction and expansion travelled in parallel lines, but in opposite directions.*

During the delightful contemplation which we have now been privileged to enjoy, in beholding this amazing union of simplicity and power, sufficient of itself to make us fall down and exclaim, "The Lord, the Lord God, great and glorious!" we have not, we think, dwelt sufficiently upon the wonderful conception of the sun having been, during the non-rotatory period, the centre of *darkness* or *attraction,* and, that it is the same still; whilst the state or condition conferred upon the *primary light* was that of *expansion.* The juxta-position in the mind of these conceptions tends wonderfully to augment our impressions of the *power* and the *wisdom* of the Creator, who could thus, at will, constrain that which of all other elements was the least disposed to condensation—the expansive principle of light—to concentrate itself around a centre, and more so

* Theorem 61.

still, when we consider, that that point was the centre of *attraction!* That the source of *light* should also be the centre of *darkness* makes manifest the consummate wisdom of God! *There* it is that *attraction*, in our system, is at its maximum, and *there*, consequently, its restraining power can be most influentially exercised in maintaining the element of expansion precisely where it is least disposed, by its innate nature to reside. Whilst the *body* of the sun, being the darkest point in our economy of the heavens, can best resist the approximation of the mass of light and heat which God has thought proper to place around it!

In a former part of this work, the identity of electricity and light was made manifest; and, while we beg to refer to what has been said, before proceeding to the consideration of any other connected branch, we shall follow up what was then done, by now endeavouring to exhibit the intimacy which exists among the various kinds of electricity themselves; in continuation, that prevailing between electricity aud magnetism; then the magnetic currents which flow round the earth; and in conclusion, of this branch of our subject, we shall show, that certain common phenomena link them all closely together into one grand and uniform whole, indicative of their common origin. We shall proceed by recapitulating what is contained in part of the *fifty-ninth* Theorem—"*That* ELECTRICITY *is a physical agent, possessing the properties of a self-expansive fluid, ... and, that although several varieties of electricity are known to exist, dependant on the manner in which the electric force is excited, yet they are sufficiently related to one another to justify the conclusion, that they all originate from a common principle, and are the effects of one individual power.*" The data which substantiate these assertions will be found detailed in the following extracts:—

"What electricity is," observes Dr. Thomson, "we known not. It is familiar to us only in its effects. We are ignorant whether it is a subtile matter of independent existence, or merely a new arrangement of molecules; nevertheless, we speak of it as material, and call it the *electric fluid* or *electricity*. Numerous as crude were the

theories of philosophers before the hypothesis of Franklin was promulgated. While he considered that it pervaded creation, he was disposed to think that friction changed its normal condition in bodies; hence arose the divisions, *plus* or *positive*, and *minus* or *negative* electricities. Another theory arose, convenient but untenable, that these electricities were altogether different, but both excited by friction, the one with *resinous* substance, the other with *vitreous*, and termed accordingly, vitreous (+) and resinous (—) electricities; this was the theory of Dufoy, which, in this country, received the support of Symmer. The theories of its *unity*, and of its *duality*, for a time disturbed the harmony of the views of electricians, but the latter hypothesis, although sanctioned by Coulumb, yielded to the truth-disclosing influence of time. Æpinus, Cavendish, and Van Marum, did much to further the views of Franklin. Peltier has proposed a theory which intimately connects the phenomena of electricity with those of light and heat, upon the undulatory hypothesis of these fluids. The *static* phenomena he supposes to result from an undue proportion of electricity; the *dynamic* to the re-establishment of electrical equilibrium between bodies unequally charged, by means of vibrations of this *electric ether*. Becquerel leans to the undulatory theory of this fluid, and the discoveries of Faraday point strongly to such a conclusion. . . . . .

"That lightning and electricity are *one*, is now firmly believed. The first suggestion of their identity is due to Stephen Gray, a pensioner of the Charter House, and Fellow of the Royal Society, &c. &c.

"These early attempts to identify lightning and electricity were eclipsed by the better conceived and ably executed experiments of Benjamin Franklin, in America. . . . . . Romas in France, and MM. Becquerel and Breschet on the Great St. Bernard, have performed the experiments of drawing electricity from the atmosphere. Mr. Crosse, of Bromfield, near Taunton, and Mr. Weekes, of Sandwich, have erected suitable means for collecting this fluid from the same source.

"By an ingenious adaptation of a modification of *Volta's eudiometer*, the latter has been able to show, through its agency, the alternate and almost momentary analysis and synthesis of water. . . . . .

"The identity of atmospheric and machine electricity has been further proved by the application of the former to electrolysis. . . . Since then chemical compounds have been frequently decomposed by Crosse and Weekes by means of their operative media; and the

latter gentleman has farther demonstrated the identity of these electric fluids, by rendering iron powerfully magnetic, by placing steel bars longitudinally within a helix connected with the exploring wire of the apparatus.

"Since the experimental proof of the unity of lightning and electricity, philosophers have pursued the enquiry still farther with the design of identifying the latter with light and caloric.

"The discoveries of Oersted, Seebeck, and Faraday show an intimate connexion. The last named chemist has very recently announced another brilliant discovery, which we shall merely enunciate, that a ray of light may be electrified and magnetized, and that magnetic lines of force may be rendered luminous. The experiments of Faraday have established a true, direct, relation and dependence between light and the magnetic and electric forces; and thus a great addition has been made to the facts and considerations which tend to prove, that all these natural forces are tied together, and *have one common origin*."*

Mrs. Somerville affords us the following evidence to the same effect:—

"In the brief sketch which has been given," she observes, "of the five kinds of electricity, those points of resemblance have been brought forward which are characteristic of one individual power. But as many anomalies have lately been removed, and the identity of the different kinds placed beyond a doubt, by Dr. Faraday, it may be satisfactory to take a summary view of the various coincidences in their modes of action on which their identity has been so ably and so completely established by that great electrician.

"The points of comparison are attraction and repulsion at sensible distances, discharge from points through air, the heating power, magnetic influence, chemical decomposition, action on the human frame, and, lastly, the spark," and so forth.

"Indeed, the conclusion drawn by Dr. Faraday is, that the five kinds of electricity are identical, and that the differences of intensity and quantity are quite sufficient to account for what were supposed to be their distinctive qualities. He has given still greater assurance

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* Introduction to Meteorology, pp. 271—278, based on the authority of the Philosophical Magazine, 1845, 1846; Athenæum, No. 953; Philosophical Transactions, 1846; Quarterly Review, clvii.; Silliman's Journal, May, 1846, No. iii.; Pouillet—Mem. de l' Inst., No. 630.

of their identity by showing, that the magnetic force and the chemical action of electricity are in direct proportion to the absolute quantity of the fluid which passes through the galvanometer, whatever its intensity may be."*

Quoting again from that inexhaustible compendium, the Encyclopædia Britannica, we are informed, that—

"In the progress of his electrical researches, Dr. Faraday found it necessary, for their further prosecution, to establish either the identity or the distinction of the electricities excited by different means; and in a paper of great value, he has established, beyond a doubt, the identity of common electricity, voltaic electricity, magneto-electricity, thermo-electricity, and animal electricity. The phenomena exhibited in these five kinds of electricity do not differ in kind, but merely in degree; *and in this respect they vary in proportion to the variable circumstances of quantity and intensity, which can at pleasure be made to change in almost any one of the kinds of electricity, as much as it does between one kind and another.*"†

These concurring evidences ought to be quite conclusive as to the point which we seek to establish—the community of principle pervading the several varieties of electricity; but should further proof be considered requisite, the numerous other authorities, on this favourite science, may be consulted, with the assurance, that a similar conclusion will be come to.

According to the order laid down we shall now proceed to enquire into the intimacy which exists between electricity and magnetism. With this design let us, in the first place, refer to the *sixty-second* Theorem:—"*That there is a strong analogy between* MAGNETISM *and* ELECTRICITY. *The agency of attraction and repulsion is common to both, and subject in them to the same laws; their intensities varying inversely, as the square of the distance between the bodies affected by them. That a like analogy extends to magnetic and electrical induction. And that there is such a perfect correspondence between the theories of magnetic attraction and repulsion, and electro-dynamic forces in conducting bodies, that they not only are the same in principle, but are determined by the same formulæ.*

* Connexion of the Sciences, pp. 352, 354. † Article Electricity, p. 574.

While experiment concurs with theory in proving that, with the exception of electrical transference, the identity of these two unseen influences is complete."

Next, we proceed, at once, to recapitulate the *sixty-fourth* Theorem as being intimately connected with the one just given, "*That the magnetic action has a circular motion round the connecting wire of a voltaic current, whose course, always constant with respect to each of the poles of a magnet, is similar to the direction of the earth and other planets around the* SUN, *and about their respective axes.*"

It will, no doubt, have been observed, that in giving the evidences respecting the several varieties of electricity, and the intimacy which subsists between them and light, we have, unavoidably, been led to give several passages strongly confirmatory of the assumptions laid down in the two foregoing theorems; a circumstance which will, at present, restrict us to a few concise quotations; while we offer this unavoidable complication as one of the best proofs that can be adduced of the similarity existing, in general, amongst all the ramifications of the EXPANSIVE PRINCIPLE, which sends forth, as it were, these various modifications of its power according to the attendant circumstances.

"From the law of action and reaction being equal and contrary," Mrs. Somerville informs us, "it might have been expected, that as electricity powerfully affects magnets, so, conversely, magnetism ought to produce electrical phenomena.

"By proving this very important fact from a series of interesting and ingenious experiments, Dr. Faraday has added another branch to the science, which he has named magneto-electricity. . . . .

"By these manipulations it has been shown, that magnets produce the very same effect on the galvanometer that electricity does; though at the time no chemical decomposition was effected by the momentary currents which emanate from magnets, they agitated the limbs of a frog; and Dr. Faraday justly observes, that an agent which is conducted along metallic wires in the manner described, which, while so passing, possesses the peculiar magnetic actions, and force of a current of electricity, which can agitate and convulse the limbs of a frog, and which, finally, can produce a spark by its discharge through charcoal, can only be electricity. . . . .

"After Dr. Faraday had proved the identity of the magnetic and electric fluids by producing the spark, heating metallic wires, and accomplishing chemical decomposition, it was easy to increase those effects by more powerful magnets and other arrangements.

"The apparatus now in use, is, in effect, a battery, in which the agent is the *magnetic* instead of the *voltaic* fluid, or, in other words, electricity."*

"It is to Dr. Faraday," observe the compilers of the Encyclopædia Britannica, "that we owe a complete analysis and explanation of the curious phenomena of rotation of a magnetical needle round an electrical current, and of a body transmitting an electrical current round a magnet, &c.

"This explanation was founded on the great discovery of the evolution of electricity from magnetism, by which Dr. Faraday laid the foundation of the new science of magneto-electricity. By means of a series of simple and beautiful experiments, ... he has clearly established the laws according to which a magnet developes magnetic currents. Dr. Faraday also applies these laws to the explanation of the reciprocal action of revolving magnets and metals, and he adduces unquestionable proofs of the production of electricity by terrestrial magnetism.

"These important results have been more recently extended by him and others. M. Pixii observed attractions and repulsions in the electricity evolved by magneto-electric induction; and by an ingenious and powerful apparatus he obtained a great degree of divergence in the gold leaves of an electrometer.

"At the meeting of the British Association, at Oxford, in June 1832, Dr. Faraday, by means of Mr. Snow Harris's electrometer, succeeded in heating a wire by magneto-electric induction.

"By means of the magneto-electric apparatus of M. Pixii, already referred to, he and Mr. Hachette decomposed water, and obtained the oxygen and hydrogen in separate tubes."

And a little further on they add—

"Before we close this brief history of electrical discoveries, we must notice the very remarkable one by M. Peltier, 1833, who has announced, that without changing the producing cause, he can trans-

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* Connexion of the Sciences, pp. 338—340. A perusal of the entire passage, too long for insertion here, is strongly recommended.—AUTHOR.

form *quantity* of electricity into *intensity*, and *intensity* into *quantity*, and neutralize two similar currents, proceeding from the same cause, by making them interfere in opposite directions."*

The perusal of these theorems, with their corresponding evidences, brings us to the penultimate point which we purposed to examine in elucidation of this particular branch of our enquiry, namely, the magnetic currents which flow round the earth. Let us begin by considering what is stated in part of the *sixty-fourth* Theorem, "*That currents of electricity analogous to these are constantly flowing round the earth, at right angles to the magnetic meridian. And by some it is considered, that the arrangement of the materials composing the outer crust of the globe may be such as to constitute a voltaic girdle, sufficient, though of feeble electric powers, to produce terrestrial magnetism.*"

And, in continuation, we shall recapitulate the concluding part of the *sixty-fifth* Theorem, "*That the laws of* TERRESTRIAL MAGNETISM, *although inconsistent with those which belong to a permanent magnet, are perfectly accordant with the conditions peculiar to a body in a state of transient magnetic induction.*"

Before we proceed to give the quotations which support these theorems, we would take occasion to direct the attention to the important bearing which some of the announcements—made by those philosophers who have studied the subject—have upon the leading features of our theory; these conclusions, themselves, arising from the discoveries which have been recently made of the more recondite laws of the subtile magnetic fluid. It is asserted by them, "that the stratified masses, which constitute the major part of the earth's outer crust, may be considered as a battery existing like a girdle around the globe, which assists to produce terrestrial magnetism, and as the channel of its currents."

When we consider the intimate connection which subsists between *light* and these *magnetic currents*, we must be convinced that there also exists as real a connection between the TIMES of the formation of the stratified mass and of the in-

* Article Electricity, pp. 574, 575.

troduction of the light; both being in accordance with the principles laid down by us. The stratified girdle required to be *first* formed, not only that it might lend its powerful aid to overcome the inertia of a world, at rest, without rotation; but that it should for ever thereafter be the channel through which the subtile streams of electricity might silently and unobtrusively circulate in beneficent and life-sustaining currents over all its habitable surface. To be more fully persuaded of this we have only to endeavour, if we can, to imagine a reverse order in the leading events of the creation—the light *first*, the stratified girdle *not* yet formed—and then we shall catch a fearful glimpse of the confusion and devastation which must have, in that case, run riot, in place of the order and harmony which now prevail; and of the fostering influences resulting from these currents which quicken and sustain every plant whose seeds and roots are imbedded in the terrestrial zone through which they flow; the vegetable kingdom most probably, not being the only one sustained in vigour and healthfulness by them.

With these remarks we have much pleasure in giving the following confirmatory passages:—

Mrs. Somerville supplies us with the first which we shall quote.

"The magnetism of the earth extends over every part of its surface," she observes, "but its action on the magnetic needle determines the poles of this great magnet, which by no means coincide with the poles of the earth's rotation."*

"In consequence of their attraction and repulsion, a needle freely suspended only remains in equilibrio when in the magnetic meridian, that is, in the plane which passes through a north and a south magnetic pole. There are places where the magnetic meridian coincides with the terrestrial meridian. In these a magnetic needle, freely

* Neither should they, according to the Dynamical Theory. The poles of rotation were determined by the direction in which the primary light affected the earth and caused diurnal motion. The poles of terrestrial magnetism arise from the light as now concentrated around the sun, and the earth's rotation. Consequently, as the centre of the originating cause was intermediately changed, that is, on the *fourth day*, so ought there to be a divergency between the poles of rotation and those of terrestrial magnetism.—AUTHOR.

suspended, points to the true north; but, if it be carried successively to different places on the earth's surface, its direction will deviate sometimes to the east and sometimes to the west of north. Lines drawn on the globe, through all the places where the needle points due north and south, are called lines of no variation, and they are extremely complicated. . . . . .

"The needle is also subject to diurnal variations. In our latitudes it moves slowly westward during the forenoon, and returns to its mean position about ten in the evening; it then deviates to the eastward, and again returns to its mean position about ten in the morning. These changes seem to be intimately connected with the motion of the sun with regard to the magnetic meridian. . . . .

"A magnetic needle, suspended so as to be moveable only in the vertical plane, dips, or becomes more and more inclined to the horizon, the nearer it is brought to the magnetic pole, and there it becomes vertical. Lines of equal dip are such as pass through all those points on the globe where the dipping needle makes the same angle with the horizon. The law of terrestrial magnetism is very complicated, and the existence of two magnetic poles in each hemisphere is more than probable. . . . . .

"All M. Hansteen of Copenhagen's lines of equal dip and variation show the existence of two magnetic poles in each hemisphere, and a comparison of the maps of the different epochs marks a change in the geographical position of the four poles. The two in the northern hemisphere move gradually to the eastward, and those in the southern hemisphere are tending westward. Moreover it appears, that in each hemisphere one of the poles is more powerful than the other, and has a slower motion. . . . . .

"The translation of the magnetic equator, the motion of the magnetic poles, the changes in the intensity of the magnetic force, and the variations of the dipping needle and the mariner's compass, have been ascribed to the heat of the sun; and M. Hansteen has even found a general resemblance between the isothermal lines and the lines of equal dip on the surface of the earth; yet in the present state of our knowledge they can only be regarded as effects of some unknown cause, and so much uncertainty prevails in the magnetic phenomena of the earth, that the results already obtained require to be continually corrected by new observations."

Further on Mrs. Somerville continues—

"M. Biot has formed a theory of terrestrial magnetism upon the

observations of M. de Humboldt, as data. Assuming that the action of the two opposite magnetic poles of the earth upon any point is inversely as the square of the distance, he obtains a general expression for the direction of the magnetic needle depending upon the distance between the north and south magnetic poles, so that if one of the quantities varies, the corresponding variation of the other will be known," and so forth. . . . . .

"When the poles were assumed to coincide, or nearly so, the difference between theory and observation was the least possible. It is evident, therefore, that the earth does not act as if it were a permanently magnetic body, the distinguishing characteristic of which is, to have two poles at a distance from one another. Mr. Barlow has investigated this subject with much skill and success. He first proved, that the magnetic power of an iron sphere resides in its surface; he then enquired what the superficial action of an iron sphere in a state of transient magnetic induction, on a magnetized needle would be, if insulated from the influence of terrestrial magnetism. The results obtained, corroborated by the profound analyses of M. Poisson, on the hypothesis of the two poles being indefinitely near the centre of the sphere, are identical with those obtained by M. Biot for the earth from M. de Humboldt's observations. Whence it follows, that the laws of terrestrial magnetism deduced from the formulæ of M. Biot, are inconsistent with those which belong to a permanent magnet, but that they are perfectly concordant with those belonging to a body in a state of transient magnetic induction. The earth, therefore, is to be considered as only transiently magnetic by induction, and not a real magnet. Mr. Barlow has rendered this extremely probable by forming a wooden globe, with grooves admitting of a copper wire being coiled round it, parallel to the equator, from pole to pole. When a current of electricity was sent through the wires, a magnetic needle suspended above the globe, and neutralized, from the influence of the earth's magnetism, exhibited all the phenomena of the dipping and variation needles, according to its position with regard to the wooden globe. As there can be no doubt that the same phenomena would be exhibited by currents of thermo-electricity, if the grooves of the wooden globe were filled by rings constituted of two metals, or of one metal unequally heated, it seems highly probable, that the heat of the sun may be the great agent in developing electric currents in or near the surface of the earth, by its action on the substances of which the globe is composed; and, by changes in its intensity, may occasion the diurnal variation

of the compass, and the other vicissitudes in terrestrial magnetism evinced by the disturbance in the direction of the magnetic lines, in the same manner as it influences the parallelism of the isothermal lines. That such currents do exist in the metalliferous veins appears from the experiments of Mr. R. W. Fox in the Cornish copper mines. . . . . .

Finally, from this writer:—

"It is moreover probable, that terrestrial magnetism may be owing, in a certain extent, to the earth's rotation. Dr. Faraday has proved that all the phenomena of revolving plates may be produced by the inductive action of the earth's magnetism alone. . . . . . From his experiments, and also from theory, it is possible that the rotation of the earth may produce electrical currents in its own mass. In that case they would flow superficially in the meridian, and if collectors could be applied to the equator and poles, negative electricity would be collected at the equator, and positive at the poles; but without something equivalent to conductors to complete the circuit, these currents could not exist."*

The compilers of the Encyclopædia Britannica confirm what has now been given on this recondite subject, when towards the close nearly of their circumstantial and elaborate article on terrestrial magnetism, they sum up, as it were, by observing:—

"In the progress of discovery it has been found, that the phenomena of the dip and the variation are more complex than the previous hypothesis will allow us to suppose; and in measuring the magnetic intensity in Siberia, M. Hansteen has proved that there is another magnetic pole in that country, which regulates the magnetic phenomena. In order to account for these, we must, therefore, suppose another magnet passing through the globe in the direction of a diameter whose pole coincides with the Siberian magnetic pole. But even this addition to the hypothesis of Gilbert will not explain the phenomena, unless we resort to the absurd assumption of Halley, who gives rotatory movements to magnetic spheres placed in the interior of the earth.

"A more sober and philosophical hypothesis is one which has long been gaining ground, and which recent discoveries have rendered still more probable. According to this hypothesis, the mag-

* Connexion of the Sciences, pp. 315, 316, 348—351.

netism of the earth is not that of a magnet, but that of a sphere or spherical shell of iron on which magnetism is induced. The difference between these two magnetic states is very great. In regular magnets the centres of action are placed at their extremities or poles; but in masses of iron, either hollow or solid, either regular or irregular, the centres of action are always coincident with the centre of attraction of the surface of the mass. When the observations on the variation and dip of the needle became numerous and accurate, philosophers soon perceived that they could not be explained by the action of the two magnetic poles at a distance from each other. M. Biot had the merit of first viewing the subject in this light, and he, at length, came to the conclusion, that the nearer the poles were taken to each other, the greater was the agreement between the computed and observed results; and, by assuming the two centres as indefinitely near to each other in the centre of the earth, the coincidence between observation and calculation was as great as could be expected. Now it is a remarkable fact, that Mr. Barlow discovered, as we have already seen, that such a coincidence in the centres of action actually takes place in all bodies which are magnetised by induction, such as iron spheres or shells; and he has applied the principle to account for the various phenomena of the dip and variation of the needle. Almost all philosophers who have since investigated the subject have adopted the same idea, and the only difficulty which now attaches to it is, where to find the cause by which the earth's magnetism is induced. The following speculations on this curious subject are hazarded by M. Hansteen, in his work on the magnetism of the earth.

" 'For these reasons, it appears,' he observes, 'most natural to seek their origin in the sun, the source of all living activity; and our conjecture gains probability from the preceding remarks on the daily oscillations of the needle. Upon this principle the sun may be considered as possessing one or more magnetic axes, which, by distributing the force, occasion a magnetic difference in the earth, in the moon, and in all those planets whose internal structure admits of such a difference; yet, allowing all this, the main difficulty seems not to be overcome, but merely removed from the eyes to a greater distance; for the question may still be asked with equal justice, *Whence did the sun acquire its magnetic force?* And if from the sun we have recourse to a central sun, and from that again to a general magnetic direction throughout the universe, having the milky way for its equator, we but lengthen an unrestricted chain, every link of

which hangs on the preceding link, no one of them on a point of support.' "*

He then states, at greater length than we can transcribe into our pages, the most admissible mode of representing the subject, in his opinion, and proceeds, by saying—

"I reckon it possible, therefore, that by means of the mutual relations subsisting between the sun and all the planets, as well as between the latter and their satellites, a magnetic action may be excited in every one of those globes whose material structure admits of it, in a direction depending on the position of the rotatory axes with regard to the plane of the orbit. Each of the planets might thus give rise to a particular magnetic axis in the sun ; but as their orbits make only small angles with the sun's equator and each other, these magnetic axes would, perhaps, on the whole, correspond with the several rotatory axes. . . . . . The conical motions by which the rotatory axes of the planets are carried round the pole of the ecliptic (the precession in the earth) joined to the revolving motion of the orbits about the sun's equator (which occasions the present diminution in the obliquity of the ecliptic) might, perhaps, in this case, account for the change in the position in the magnetic axis. It would greatly strengthen this hypothesis, if the above great magnetic period, after the lapse of which both axes again assume the same position, should, in fact, be found to coincide with the period of precession, which, however, seems a little doubtful.

"Such," resume the compilers, "was the state of speculation on this part of the subject, when M. Hansteen published his work on the magnetism of the earth. The poles of our globe were then regarded as the coldest parts on its surface ; and no conjecture ever had been hazarded regarding the connexion between the phenomena of terrestrial temperature and terrestrial magnetism, till Sir David Brewster proved, from an immense number of meteorological observations, that there were in the northern hemisphere two poles of maximum cold; that these poles coincided with the magnetic poles; that the circle of maximum heat, like the magnetic equator, did not coincide with the equinoxial line; that the isothermal lines, and

* If M. Hansteen would but consent, we think his scientific and enquiring mind would be brought to rest, by belief in the sublime truths enunciated thousands of years ago, that, "God said, Let there be Light." And again, "God set them in the firmament of heaven." Genesis i. 3, 15.

the lines of equal magnetic intensity, had the same general form surrounding and enclosing the magnetic poles and those of maximum cold; and that by the same formulæ, *mutatis mutandis*, we could calculate the temperature and the magnetic intensity of any point of the globe."*

In fulfilment of the plan which we proposed to ourselves for the investigation of this particular branch of our subject, we have only now to sum up what has been said, by exhibiting, as closely as in our power, the intimate relationship which subsists between what we are disposed to consider as mere varieties of one great and comprehensive power. Let us commence, as is our wont, by recapitulating the Theorem which has reference to this point. In the *sixty-sixth* it is stated:—"*That in light, heat, electricity, and magnetism, principles are exhibited which, although they do not occasion any appreciable change in the weight of bodies, manifest their presence by the most remarkable mechanical and chemical effects. And that these agencies are so connected as to afford every reason to believe they will ultimately be referred to some one power of higher order, in conformity with the general economy of the system of the world; in which the most varied and complicated effects are produced by a small number of comprehensive laws.*"

In elucidation of this propositional method of stating these truths, and while we have consideration to the recent frequent allusions which have already been made to the intimate relationship which subsists between these kindred branches of the expansive principle, we shall take occasion to give only one quotation, which forms also a brief summary of Mrs. Somerville's observations on the same subject:—

"In light, heat, and electricity or magnetism," she observes, "nature has exhibited principles which do not occasion any appreciable change in the weight of the bodies, although their presence is manifested by the most remarkable mechanical and chemical action. These agencies are so connected, that there is reason to believe they

* Magnetism, pp. 750, 751. We recommend our readers to peruse, if convenient, the whole of this most elaborate and circumstantial article.—AUTHOR.

will ultimately be referred to some one power of a higher order, in conformity with the general economy of the system of the world, where the most varied and complicated effects are produced by a small number of universal laws. These principles permeate matter in all directions; their velocity is prodigious, and their intensity varies inversely as the square of the distance. The development of electric currents, as well by magnetic as by electric induction, the similarity in the mode of action, but, above all, the production of the spark from a magnet, the ignition of metallic wires, and chemical decomposition, show that magnetism can no longer be regarded as a separate, independent principle. That light is visible heat seems highly probable; and although the evolution of light and heat during the passage of the electric fluid may arise from the compression of the air, yet the development of electricity by heat, the influence of heat on magnetic bodies, and that of light on the vibrations of the compass, show an occult connexion between all those agents which probably will one day be revealed. In the meantime it opens a noble field of experimental research to philosophers of the present, perhaps of future ages."*

These diversified investigations, which have occupied our attention almost exclusively since the commencement of this section, have been absolutely necessary, in order to show, in the first place, that the light could *not* have been concentrated around the sun during the period when those works of the Creator, which are recorded in verses 3 to 13 of the first chapter of Genesis, were going forward. In the next, that it is *only from Scripture* that any information can be derived of the means and the power by which the light, after it had performed these works, was concentrated around the middle orb of the planetary system. Again, that when the darkened nucleus of the sun was thus illumined, no matter possessing gravity was added to it. And, ultimately, that the light which radiates from the sun, does not proceed from it as from an encandescent body, but from a circumfluent luminiferous atmosphere, in strict conformity with the spirit, and we might add, almost with the very words of this announcement of Scripture, which was made upwards of thirty-two centuries ago—

* Connexion of the Sciences, p. 355.

"Let there be luminaries in the firmament of the heaven." The perfect harmony which is thus shown to exist between those various points—where exceptions even render the coincidence more complete—and the words and spirit of Scripture, must, we should think, occasion a thorough conviction of the truth of the inspired narrative. Indeed it is hard to conjecture what degree of coincidence will be sufficient to carry perfect conviction to the mind, if the evidences, which we have succeeded in bringing forward, do not produce this desirable result.

SECTION IX.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XL.

The general train of argument of the preceding chapter continued. The Scriptural announcements with reference to this era of the earth's history examined, and compared with scientific evidences. Reflections which present themselves by a comparison of these two sources of truth, and some observations in furtherance of the principal doctrine of the Dynamical Theory, namely, *the previous non-rotation of the earth during a long but indefinite period.*

HAVING, by what has been stated in the foregoing chapter, so far accomplished the object of our present research, we shall, as a commencement to this, proceed to enquire into such remaining points, as may—with the assistance of philosophy and Scripture, mutually reflecting light on each other—tend to carry on our argument in favour of the extreme position we have all along assumed, *the previous non-rotation of the earth during a lengthened but indefinite period.*

Before we proceed, however, we take occasion to make an observation, which, perhaps, ought to have been made sooner. We allude to the singular *difference,* which has been made apparent, between *expansion,* the force which has twice caused the spheres to revolve, and *gravitation,* which, as regards their motions, seems to have been only once employed, namely, when they were translated in space. This latter, it will have been observed, acts solely according to the *mass,* without reference to *quality* or *form.* Light, Electro-magnetism, or Expansion, if we will, descriminates most critically, both as to *materials* and

form, but is apparently disregardful of *mass*. The magnificent Sun, and the asteroid Ceres, being equally under its influence, and wheeled by it around their respective axes! This is very important, and serves, in another aspect, to show us how *diametrically different* these two all-pervading forces are; while it leads us to the consideration, that it behoved the Creator, in the plenitude of his wisdom, thus to create instruments entirely different, when he wished to produce effects wholly diverse, in order that he might complete materialism, and place the orbs of the universe within the secure grasp of two opposing forces!

We shall now endeavour, in following up our discourse, to dispose, first, of the evidences which are afforded us in Scripture, commencing with that which follows in regular sequence, and is so frequently repeated in somewhat diversified terms. We allude to the first effects which the "*luminaries*" thus placed "in the firmament of the heaven" were destined to produce, namely—to "divide the day from the night" (or, as the marginal reading renders it, "*to divide between the day and between the night*"), "the greater light to rule the day, and the lesser light to rule the night," (marginal reading, "to be the rule of the day"); and again at the 18th verse, "to rule over the day, and over the night, and to divide the light from the darkness."*

In whatever attempt we may make to reconcile the corresponding parts of science to these new laws, which were thus instituted, when the light was concentrated around the sun, and made to reach us from that source as well as by reflection from the moon, we must adhere steadily to the general rules formerly laid down for our guidance in such cases, namely, that every announcement, recorded in the first chapter of Genesis, impressed a new law upon matter; or rather, added a law to the code which now constitutes nature itself; and by implicit confidence in this undeniable truth, we hope to be led to a proper exposition of the effects of those laws on the phenomena around us. In doing this, we shall commence by tracing the words first used to their true origin and signifi-

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* Genesis i. 14—18.

cation. "The day" and "the night," mentioned in the fourteenth verse, correspond precisely with the same words in the fifth verse, which are shown to have originated from "the light" and "the darkness;" and thereby agree with the tenor of the eighteenth verse, in which it is recorded, that the luminaries thus formed were "to divide the light from the darkness." But the *light* and the *darkness*, as we have already seen, correspond to our terms *expansion* and *attraction;* and, therefore, we may conclude, that the luminaries were *to divide attraction from expansion*, or to *divide between attraction and between expansion.*

Now, by keeping in mind what was formerly inculcated, *that no two laws—conferring the power to produce the same effects by the same cause—could possibly have been promulgated by the Omnipotent, we shall be enabled to conclude, that there must have been an essential difference between the nature of the luminaries now willed into existence and the light which was formed at first;* because, as the light was *then* divided from the darkness, had these two kinds of light been essentially the same, the repetition of this power "to divide the light from the darkness," or expansion from attraction, would have been tantamount *to have twice conferred the same faculty on the same cause*, which by the foregoing rule is excluded from our supposition, and, therefore, as the power now conferred is a perfect repetition of what was impressed upon the light on the *first* day, we are shut up to the conclusion, that the luminaries, instituted on the fourth day, differed in some very essential requisite from the light which was first formed. The *essential* nature of that difference may not perhaps be very easily explained; but we shall endeavour to make it apparent *that a difference did, of necessity, exist between them.*

In the definition given of attraction by Sir John F. Herschel, he has shown, that it proceeds in lines passing through the sun's centre; and we trust no one will deny the fact, that the general direction of expansion or repulsion (setting aside for the present, as irrelevant, its *undulatory* motion), proceeds from the sun to the circumference; consequently, these two influences *must pass each other in parallel lines.* But as under these names they are merely abstract principles—whose

existence is only known and acknowledged by the effects which they produce—never having been appreciated themselves directly by the senses, no one has any difficulty or evinces the slightest hesitation in admitting, that *attraction* and *expansion*, *whatever may be their ultimate or intimate nature or origin*, *must pass each other in parallel (and, considering their ubiquity), in closely proximate lines.* This is a truth with which most people will readily acquiesce, merely because it is of so abstract a nature as to appear to be wholly independent of the laws which usually govern matter; every one admitting that these influences must act in such a manner as to pass each other, but very few considering how this is accomplished, or whether they occupy space in their transit, or are as immaterial as they are imperceptible.

It may, perhaps, assist the mind to come to a more correct understanding on this abstruse subject, to transfer our thoughts progressively from the contemplation of such abstract truths, to the more material conception of its being *Light* and *Darkness*, in place of *repulsion* and *attraction*, of which we are now treating. For, if it can be so easily conceived and so readily admitted, that the attractive and expansive principles proceed in contrary directions but in parallel and proximate lines; then there can be no longer any objection, untinged with prejudice, to admit the truth we are contending for, namely—that *Light and Darkness do the same.*

But *light*, and it is presumed *darkness* also, must be material, although existing in a state altogether distinct from what we usually consider matter to be. Experimental philosophers, as we have already made abundantly evident, have no hesitation in asserting, that they can refract and reflect a pencil of light, separate it into its component colours, and even divide it by polarization into two distinct parts, having opposite poles,* although the moment its *materialism* is alluded to, a pause of doubt and dilemma seems to ensue, as if it were too much to concede, that what can thus be *manipulated is material!* Yet it must be so; for can that which is *not* material be so subjected to change by the intervention of

* Theorem *thirty-nine*, to which please refer.

a crystal prism, or a cube of Iceland spar? or can it be subjected to change at all? But should refuge be taken in the not unusual assertion, that it is not material, but merely a change in the *condition* or *state* of matter, merely a variety of motion, it may be asked, can immaterialism be subjected to motion? or can that which is immaterial affect the external eye? cause all the varied phenomena of colour? produce the diversified effects of heat, or those more surprising ones of chemical composition and decomposition? Certainly not. But if the *light* be thus material, so must likewise be the *darkness*, for the modifications of light affect darkness; and only that which is material can be subjected to the modifications of materialism.

It will contribute still further to assist us in reining in our ideas from the regions of abstraction to the more material conceptions now offered to our contemplation, to be made aware, that experimenters cannot take up any ray of light from the sun, the moon, the fixed stars, or from the electric flame, for the purpose of subjecting either of these to the surprising manipulations their dexterity and skill enable them to perform, without, at the same time, including in each ray, so set apart, upwards of *six hundred darkened bands*, or *bands of darkness*. An interesting, but hitherto isolated discovery in optics, forming the subject of the *forty-first* Theorem, but which seems to have a tendency to elucidate, when more and more appreciated, what we are now treating of; for it is not a little remarkable, that the rays of light proceeding from those bodies of the universe, whose attractive powers are the greatest, and to which, according to this Theory, darkness ought to propend, should be those which are crossed throughout with such innumerable darkened bands.

On this interesting optical phenomenon we find Dr. Thomson thus expressing himself:—

"A beautiful discovery of Wollaston and Fraunhofer has demonstrated a deficiency in the pencil of solar light, supposed to arise from absorption in the sun's atmosphere. When the spectrum is received upon the object glass of a telescope a number of dark bands are found uniformly present. These spaces are supposed to arise from the cause mentioned. But what is the nature of the subtile

fluid of which we speak? As yet we are ignorant. Nevertheless, two theories have been proposed and ably supported. It is foreign to our object to examine these hypotheses, suffice it merely to name them. The one is the *emission theory* of Newton; the other is the *undulating* theory of Huygens and Dr. Thomas Young. By the former light is assumed to be material and darted from self-luminous bodies; by the latter it is believed to reside in a subtile fluid, an ether, pervading space—luminous when in motion, dark when in repose. By the undulatory theory, the particles of this ether are supposed to be easily agitated and cast into regular vibrations, propagating the motion like a ripple on the water. The intensity of light is believed to depend upon the extent of the undulations, its colour, upon their frequency."*

Before we proceed farther, we shall take occasion to make a few observations, bearing on an idea which we have formed on this particular point, although we offer both as scarcely more definite than mere suggestions.

The idea is this. Commencing with what may be termed the initial reasons, we may affirm that all analogy warrants our supposing, that besides communicating visual light or even warmth, the rays which emanate from the sun, and those reflected from the moon, perform other and more recondite functions. Every investigation hitherto made into the constitution of light, shows it to be of a peculiarly compound nature; "it can be decomposed into primary and secondary spectra; it can likewise be polarized or separated into pencils having distinct and opposite poles."† "The solar rays are admitted by all to possess chemical properties."‡ "It occasions very material and diversified effects on the vegetable kingdom."§ "Its union with some radicle or base resolves the same into the gaseous state."‖ And lastly, "That there is an intimate connexion between, light, heat, electricity, and magnetism."¶ In truth, we could expect no other results, when enquiring into that which has been made to perform so important a part in the general economy of nature, and which was employed as the *primum mobile* in so many great events of the creation.

* Introduction to Meteorology, p. 80.

† 39th Theorem.

‡ 40th Theorem.

§ 44th Theorem.

‖ 45th Theorem.

¶ 66th Theorem.

It is not our intention to dwell on this topic at present, nor to delay the general argument in working it out, however interesting and fecund it may be, yet in a cursory manner we shall specify the grounds of our belief, and point with more especiality to the character of those "more recondite functions" which we suppose the sun and moon to perform with regard to the earth, and its meteorological vicissitudes.

"*Electrical induction* is that remarkable influence which is exerted by electrified bodies on other bodies, at such distances as to prevent the transfer of any part of the charge, but by which a polar state is communicated to the body under induction, so as to confer upon it equal but opposite powers by a common condition."*

"That the most intense heat is generated by electrical action, especially by voltaic electricity; and some eminent philosophers are inclined to attribute the light and heat of the sun to electrical agency."†

"That although the laws of *terrestrial magnetism* are inconsistent with those which belong to a permanent magnet, they are perfectly accordant with the conditions peculiar to a body in a state of transient magnetic induction."‡

"That the moon is a non-luminous body which receives its heat from the sun, its light and heat from the sun and earth;§ that consequently, the light which it sheds on us is the reflected rays of the sun; and, that after repeated experiments it has been found, that the light received from the moon possesses no traces of heat.||

"That the angle at which light falls on any object very materially affects the nature of the results."¶ And, lastly, that *dissimilar* causes cannot, in the ordinary course of things, produce *similar* effects.

The validity of these postulates being admitted, we are enabled, by their means, to enter upon our argument.

The light and heat of the sun being considered of electrical origin, as well as light, heat, electricity, and magnetism being

* 65th Theorem. † 61st. Theorem. For this opinion in detail, see Astronomy, by Sir John Herschel. ‡ 65th Theorem. § 9th Theorem. || Heat, in Cab. Cyc. p. 351. ¶ 39th Theorem.

derived from a common source, and the earth being looked upon as transiently magnetic, or electrified by induction, we are warranted in concluding, that this peculiar state or condition, with respect to these subtile fluids, has been induced upon the earth by the *influence of the sun's rays*, as the former circulates round the latter.

These influences continuing ever of the same *in kind*, must, if they produce any such effect at all, always induce electricity of *the same kind on the earth;* whether *positive* or *negative* affects not the question. Let us, therefore, for argument's sake, suppose it to be of the *positive* kind.

But light from the sun is not the only light we receive externally, although it be the only light accompanied by heat. We receive also rays of light from the *moon*, but of a different *kind* from the former; separated from its usual concomitant it is shed upon us indirectly, and comes at various angles, according to our relative positions with respect to the solar fountain. Proceeding on the assumption, that these heavenly bodies are the inducing causes of the electrical or magnetical state of the earth; remembering that the angle at which light falls on any object very materially affects the nature of the results; and taking into account the entire difference between the light received from the sun, and that shed upon the earth by the moon, we consider ourselves authorized, as before, to conclude, that while *it*, too, is constant as to *kind*, it cannot be of the *same description* as that received from its primary, "*dissimilar* causes not being able to produce *similar* effects;" and, as there are only two *kinds* of electricity known, it follows, that if the sun's influence is *positive*, this induced by the *moon* must be *negative*.

We have so far advanced in our argument as to have reached a point whence we may look upon the *sun* as the generator of, or ruler over one kind of electricity; and upon the fair orb of night as the generator of, or ruler over another description of the same elastic all-pervading fluid.

If the *positive* electricity be induced by, or originates from the light and heat which surrounds the sun, or, in other words, if light and heat be its equivalent, then the precisely opposite condition of materialism, or *darkness*, must be the perfect

equivalent, in the solar economy, for the *negative* state of electricity. But immediately after the separation of light from darkness, the light was, in scriptural language, called *day*, and the darkness was called *night*. Consequently, in place of the light we have *day* for the equivalent of *positive* electricity, and *night*, in a similar manner, as the synonyme of the *negative* kind; and having come to this conclusion, we have only to take up the assertions of science, which we most heartily do, and consider the earth to be rendered "*transiently magnetic by induction*" by the sun's rays, and reflect upon the periodical interposition of the moon, and the variety of the lunar phases inducing *a different kind* of electricity upon the earth, being shorn of heat, which is expansion, to become fully aware of the very important functions which our lunar attendant must perform in the general economy of the seasons, and the influence which the interference of its electrical agency must exercise over our meteorological vicissitudes! But in addition to the effects produced by her augmenting and waning phases, the direct interposition during one period, and her full opposition at another, must occasion a very notable modification of the sun's electrical inductive influence upon the earth. Indeed, we can hardly imagine a contrivance of more simple grandeur and efficiency than the periodical interposition of another body between the electrify*ing* and the electrifi*ed* orbs, the passive earth subject to the overwhelming power of the great central luminary around which it revolves, hopeless of any change in the state which its great inductor is inducing upon it, until relieved by the monthly circuits of her attendant orb, whose interposition for a moment breaks or intermits the current, and succeeds in producing the most delightful and healthful vicissitudes of the all-pervading electrical influences.

Nor is this the only service it performs. On the contrary, although the most essential, it is, perhaps, the least appreciated; nevertheless, in this respect it has the impress, and partakes of the mannerism which characterizes all the works of God. Ever beneficent, they are made to sub-minister, in various ways, at the same time and by the same act, to the welfare of the beings which he has created, and for whose benefit the arrangements of his providence are all designed.

Let the indwellers and wayfaring men of the tropical regions, scorched by the incessant and intolerable heats of a vertical sun, bear testimony to the blessing of light *without heat*, which is shed upon them, and upon their paths, by the cloudless rays of the attendant moon!

But to revert to the more rigid line of our argument. We may be enabled, from what has been advanced, to perceive the aptitude of the terms used in Scripture, wherein it is said, that "God made two great lights; the greater light to rule the day, and the lesser light to rule the night; and set them in the firmament of the heaven to give light upon the earth;" for it was by "giving light upon the earth" that they fulfilled the design of their appointment; while the comparative terms "greater" and "lesser" may, with as much propriety, apply to the *quality* of the light as to the *quantity, or extent of radiating surface*. The "greater" light was the *fiercer* light, accompanied by heat, and imparted directly, and so producing all the effects which *it* is calculated thus to occasion. The "lesser" light, again, was that which is shed upon us by reflection, and shorn of its inherent heat; consequently, capable of originating results very different from the other, although in strict conformity with the words of Scripture, they both "gave light upon the earth."

This observation will lead us, at last, to the conclusion we are desirous of coming to.

That the *sun*, in being thus the immediate secondary cause, or the generator of one of the states of the electrical fluid, whose synonyme is *light*, or *day*, and proportioning the supply of this, always constant as to *kind*, according to its relative position to any given point of the earth's surface, could not be more appropriately designated than by being called "*the ruler over the day*;" while the moon, or lesser light, in having the same office to perform with respect to the other condition of this self-expansive, unseen principle, whose equivalent is *night*, communicating its elemental influence in varied degree, according to its several and successive phases, is, likewise, most aptly denominated, "*the ruler of the night*;" both one and other of these glorious orbs—and, likewise, the two together—accomplishing, by their numerous and varied com-

binations, and by the intermingling of their effects, a never-ending and beneficent change of seasons on the earth, and useful vicissitudes in its meteorological economy.

A convincing corroboration of this train of thought—which, in the imperfect condition of scientific data in this particular branch, we offer as a mere idea—may be found, we think, in the non-existence of the ethereal fluid, and of these electrical alternations and vicissitudes previous to the rotation of the earth, and the illumination of the sun. In the then condition of the material universe, each revolving sphere having been enveloped in water, and inhabited by such organisms as could exist in immersion only, these changes were not needful, nor could they have been appreciated by them; and, therefore, consistently with the plan, laid down from all eternity, the luminiferous elements were not called into existence until the creation had reached that stage which rendered their introduction essential, as the secondary means of perfecting the whole.

There is yet another and a very important conviction which, in consequence of what has been said in a previous section, must have presented itself again to the mind, namely, that if light and darkness be material; be both possessed almost of ubiquity; and move or proceed in *opposite* directions—while it is one of the surest axioms in mechanics, "that when bodies moving in opposite directions impinge upon, or come into contact, the one is destroyed by the other if unequal in force, or neutralized if equal"—it may be demanded, how can light and darkness, incurring in all these conditions, escape the consequences of this general law of matter declared by mechanics? According to the common course of events—of natural cause and effect—no answer can be given to this valid objection. It, therefore, seems to illustrate the supremacy of the Word of God. This, alone, can extricate us from our dilemma; for, it is written, that "*God divided the light from the darkness;*" and that the luminaries, of whose formation we are now treating, were ordained to do so likewise—"to divide the light from the darkness;" and thus, by a special and supreme decree of exception in their favour, promulgated by the great lawgiver of Nature, they were to enjoy the unique privilege of travelling

almost ubiquously in opposite directions, yet so as never to impinge upon, nor destroy each other's influence! a result which we can the more readily and fully appreciate in exact proportion as we are convinced of the almost infinitessimal degree in which alone those influences, light, heat, and darkness participate in materialism; their abstraction from the laws common to matter also rendering them less liable to the accidents common to material bodies, when, in moving in opposite directions, they impinge upon each other.

There is, in fine, no aspect in which we behold the works of God without observing fresh instances of unspeakable wisdom, and of experiencing additional motives for admiring them, and for adoring the common Creator.

SECTION IX.

CONCENTRATION OF THE LIGHT AROUND THE SUN; AND THE COMPLETION OF THE WORK OF CREATION.

CHAPTER XLI.

The subject, of a change in the direction of the primary light, continued. Applied to the truths previously elucidated, and deductions drawn in favour of a by-gone period of non-rotation. Confirmatory conclusion deduced from the fact, that the illumination of the sun was the remaining cause of the commencement of "signs, seasons, days, and years." Astronomical explanation of the vicissitudes of season. Application of the uranographical phenomena to the point under discussion. Concluding testimony: that which is borne to the correctness of our hypothesis by the creation, at this particular juncture, of the several races of animated beings which are dependant alike for motion and existence on atmospheric air. Termination of the evidences in favour of the Dynamical Theory.

We shall commence this chapter by considering a resultant consequence of what has been so clearly made out, and has occupied our attention so much in the former divisions: the perfect parallelism in which the influences of attraction and expansion, or of darkness and light, proceed *from* a centre and *towards* a centre; and shall blend this with some of those facts which have been previously established, namely, that the *direction* of the force of gravity has ever been invariable; that light proceeds in straight lines; and that it did *not* occupy its present centre, around the sun, during the first three days of the Mosaic week.

By the blending of the former truth, the parallelism of light and darkness, with the three latter ones, we shall be constrained to conclude, that as the direction of gravitation in our system has *ever been* from the periphery *towards* and *through* the

sun, as a centre; and as the rays of light, in coming *from* their present centre, travel in a parallel direction to the others,* *this could not have been the case when the light was not situated where it is at present;* because that which "travels in *straight lines*" could not have proceeded from any *two distinct points to the circumference by the same path;* and, therefore, as they *now* run parallel to each other, and one of them has been *invariable,* they must *formerly* have crossed each other with an obliquity commensurate to the obliquity of their respective centres of convergency and divergency; and as dissimilar causes cannot produce similar effects, and it has been laid down, as a fundamental principle of this Theory, that the words of the first chapter of Genesis form *the constitutional code of all materialism,* we should expect to find, as a necessary consequence of these premises, that on the light having been concentrated around the sun, on the fourth day of the Mosaic week, it must have undergone a very important change of character, corresponding to the change of *relative* position from obliquity to parallelism; and by admitting this change of character, which cannot be denied, we perceive the *necessity for the command which re-endowed it with powers, which it could not have had, in consequence of the change which took place in itself,* unless we permit our minds to conceive that *two distinct* causes are capable of producing the *same* effect. Nor should we pass on from the contemplation of this great truth, without sufficiently bringing to mind, the all-important difference in the effects which would flow from this relative difference in the direction of these two potent and almost omnipresent forces. This subject is well deserving of every consideration, and of being wrought out with much more care and attention than the limits and plan of our work will permit us to bestow upon it. Nevertheless, what we have said has brought out, into clear and beautiful manifestation the propriety, nay, the necessity, for the command, that the lights which were placed in the firmament of the heaven,

* See 43rd Theorem. By this we merely mean to express the conception that the general course of the undulations of a ray of light will be a straight line from the luminary causing it.—AUTHOR.

should be ordained to "rule over the day and over the night, and divide the day from the night, the light from the darkness;" which command, as an approximative repetition, threatened to embarrass, and even to destroy one of the great principles on which this theory is based. Indeed, every step we take in scrutinizing the more secret laws which govern the material world, only shows, more convincingly, that the sacred historian precedes us; and, that directed by the same unerring wisdom which framed them all at first, he has revealed to us, thousands of years ago, in the plainest and most concise terms, those very truths which appear to be but now unveiling themselves, as the rewards of the industry and assiduous research of modern philosophy!

But there is another and a very important inference which is to be drawn from the *divergency* of directions here alluded to; for LIGHT, which did *not* run parallel to DARKNESS, could not produce the *same* effects as that which does. This conception will strongly corroborate the assumption we have so frequently adopted and applied, namely, that the primary light, though perfect in itself, was not in every respect identical with that which now proceeds from the sun. It was light, but it was light in a different state, coming from a different point, and evidently running obliquely to the direction of *attraction*.

We must next, in prosecution of our general argument, proceed to a brief consideration of the indirect but peculiar bearing of the remarkable announcement; that the sun, *by being illuminated on the fourth day of the Mosaic week*, became, to the earth, the cause of "signs, seasons, days, and years;" in doing which we shall become convinced, that the mere *putting of this command on record* upwards of three thousand three hundred years ago, affords the most undeniable evidence, that the recorder was an inspired amanuensis of the Deity. While we take occasion to observe, that as we are now dealing with a class of facts which occurred *after the earth had rotation impressed upon it*, and the source of whose influence is altogether exterior to it, they can only confirm our theory incidentally, or as far as they necessarily involve, in themselves, an undoubted foreknowledge of events proved by the dynamic system to

have taken place previously, but which were wholly unknown to the world's inhabitants at the time when these announcements were put on record; whereby proving *their* heavenly origin, and consequently the source of all other assertions in the same portion of Scripture, they shed back, by reflection, a convincing stream of evidence on what we may have assumed in reliance on these announcements, and on the validity of scientific discoveries and deductions. The present instance is one peculiarly in point. The evidence consists in the knowledge which the *ultimate writer* of that article must, at that time, have possessed of the true motions of the heavenly bodies of our system. To the act of directly illuminating the sun and the moon indirectly, are ascribed results which, of necessity, involve one of the two following consequences: that the writer was aware that the earth was impressed with a double movement in space, one around the sun, and the other around its own axis; and also, that the moon circulated in its orbital course around the earth; and, with this knowledge, he ascribed *to the lighting up of the central orb, and to the reflection of its rays from the moon*, the causing of signs, seasons, days, and years, as these actually do; besides, he must have been aware of a still more recondite truth, which we trust presently to establish, namely, that the lighting up of the sun and the movements of the heavenly bodies, *could not have caused the vicissitudes of the seasons, unless the primeval light had once occupied a distinct centre, and put forth energies of a peculiar description.* This is one view of his position; the other is, he was entirely ignorant of these truths, and merely lent himself as an implicit but unconscious instrument to register what he did not himself comprehend. But whether we consider the writer to have stood in one or other of these positions, when all these considerations are duly weighed, it must appear evident to every candid and impartial mind, that even after awarding to eastern astronomy the utmost advance it can in justice lay claim to, the Jewish historian could not have been instructed in what he has recorded by any *mere human* intelligence; and, therefore, if, on the one hand, he was aware of their full import, and understood what he wrote, he must have received that knowledge from a divine source; while, on the other hand,

if he registered these sublime and recondite truths unconsciously, without understanding their meaning, he must likewise have done so at the dictation of a spirit more than human; and, as that which he has recorded is *truth*, that spirit must have been of God—must have been the Spirit of Truth.

To make more palpably manifest the gross ignorance which long prevailed respecting the two orbital motions of the heavenly bodies, and the reluctant incredulity evinced to believe in the true, the Copernican system, we give the following extracts, while we make no apology for doing so, as nothing could be better expressed or more appropriate:—

"It is seldom easy," observes Mr. Nichol, "to ascertain why or how a new truth is revealed, that majestic event usually occurring when old systems seemed to have reached their climax and achieved perfection. When, however, the still small voice comes it is one of dread. The accomplished part of the world feels as in an earthquake, although the deserts may rejoice at the rising light. The obscurity of the times in which Copernicus lived rests over his early character. We know not how far favourable circumstances contributed to the development of his genius; or whether, without peculiar advantages, he owes all to an inborn energy. But, whatever his mental culture, the greatness of his mind could be borrowed from no one; inasmuch as he was the earliest to accomplish a task most difficult for man. . . . . . He threw from him the weight of ages, and quietly asked whether that fundamental tenet, which asserts that the earth is motionless, might not be false.* The mental effort required, even to hesitate on a point which all mankind had up to that moment undoubtingly believed, and which had now interwoven itself with every mode of thought, was an achievement for the loftiest order of genius; the question once put, it required only superior but not uncommon talent, to follow it to its conclusions. . . . . . Modesty, a characteristic of the finest minds, induced Copernicus, after he had obtained sight of this great idea, to search through the ancient philosophies, lest there might be precious relics buried there, to confirm

* "I have seen it stated," he adds in a foot note, "that Copernicus was a great man by accident—that he owes his name to a happy conjecture! Let the authors of this opinion review the whole history of mankind, and reckon the number of such happy conjectures!

and encourage him; and accordingly he did find certain hints, touching on a simpler order of things, which his correct and discriminating intellect speedily methodized into that system which, in the somewhat hyperbolical language of his successor, Tycho, 'moved the earth from its foundations, stopped the revolution of the firmament, made the sun stand still, and subverted the whole ancient order of the universe.' . . . . . Using the best means within his reach, he constructed a theory of the apparent motions of every planet; and the results corresponded so closely with observation, and offered so thorough an explanation, that nothing was left to his opponents but the interposition of mystical arguments. This illustrious man received the proof copy of his work on his death bed."*

Sir John Herschel, though in more general terms, bears testimony to the same facts, when he informs us that:—

"As the decisive mark of a great commencing change in the direction of the human faculties, astronomy, the only science in which the ancients had made any real progress, and ascended to anything like large and general conceptions, began once more to be studied in the best spirit of a candid philosophy; and the Copernican or Pythagorean system arose or revived, and rapidly gained advocates. Galileo at length appeared, and openly attacked and refuted the Aristotelian dogmas respecting motion, by direct appeal to the evidence of sense, and by experiments of the most convincing kind. The persecutions which such a step drew upon him, the record of his perseverance and sufferings, and the ultimate triumph of his opinions and reasonings, have been too lately and too well related by Mr. Drinkwater to require repetition here. By the discoveries of Copernicus, Kepler, and Galileo, the errors of the Aristotelian philosophy were effectually overturned on a plain appeal to the facts of nature; but it remained to show, on broad and general principles, how and why Aristotle was in the wrong, to set in evidence the peculiar weakness of the method of philosophizing, and to substitute in its place a stronger and better. This important task was executed by Francis Bacon, Lord Verulam, who will, therefore, justly be looked upon, in all future ages, as the great reformer of philosophy, though his own actual contributions to the stock of physical truths were small, and his ideas of particular points strongly tinctured with mistakes and errors, which were the fault rather of the

* Contemplations of the Heavens, pp. 13, 14, 21.

general want of physical information of the age, than of any narrowness of view on his own part, and of this he was fully aware."*

We have asserted above, that the illumination of the sun could not alone have caused it to produce the vicissitudes of seasons which we now experience, unless the light had once occupied a distinct centre from that which it does at present. It shall now be our care to substantiate that assertion by reference to the discoveries of modern science; it being a fact which will serve, in a remarkable manner, to bring out the truth of the divine record. Let us then, first of all, see what is stated in the *sixth* Theorem:—"*That the vicissitude of seasons experienced by the* EARTH *is owing to its globular form, the obliquity of the plane of the equator to that of the ecliptic, the parallelism of the earth's axis, and to the orbital motion of the earth around an illumined sun imparting light and heat.*"

The following evidences, upon which this theorem is founded, will, we trust, be perused with attention.

Mrs. Somerville in showing that the mean temperature of the earth has not varied, bears testimony to the invariable length of the *day*, by the following pointed expressions:—

"In consequence of the rotation of the earth being a measure of the periods of the celestial motions, it has been proved that, if the length of the day had decreased by the three-thousandth part of a second since the observations of Hipparchus, two thousand years ago, it would have diminished the secular equation of the moon by 4″ 4. It is therefore beyond a doubt that the mean temperature of the earth cannot have sensibly varied during that time."

While, as regards the stability of the seasons, the same writer gives forth as definite an opinion, thus:—

"The plane of the ecliptic itself," she observes, "though assumed to be fixed at a given epoch for the convenience of astronomical computation, is subject to a minute secular variation of 45″ 7. occasioned by the reciprocal action of the planets. But, as this is also periodical, and cannot exceed 2° 42′, the terrestrial equator, which is inclined to it at an angle of about 23° 27′ 38″ 25, will

* Discourse on Natural Philosophy, Cab. Cyc. pp. 113, 114.

never coincide with the plane of the ecliptic; so there never can be perpetual spring. The rotation of the earth is uniform; therefore day and night, summer and winter, will continue their vicissitudes while the system endures, or is undisturbed by foreign causes."*

"Henceforward, then," says Sir John Herschel, "in conformity with the Copernican view of our system, we must learn to look upon the sun as the comparatively motionless centre about which the earth performs an annual elliptic orbit, the sun occupying one of the foci of the ellipse, and from that station quietly disseminating on all sides its light and heat, while the earth, travelling round it, and presenting itself differently to it at different times of the year and day, passes through the varieties of day and night, summer and winter, which we enjoy. In this annual motion of the earth its axis preserves, at all times, the same direction as if the orbital movement had no existence; and is carried round parallel to itself, pointing always to the same vanishing point in the sphere of the fixed stars. This gives rise to the variety of seasons."†

"Having thus cursorily noticed the peculiarities of the earth's surface," observes Dr. Thomson, "we pass to a hasty examination of the motions of our globe upon its axis and round the sun. By the one we have the division of the time into days and nights, by the other into years. It is important that we should consider more particularly the latter motion, for to it, together with the inclination of the earth's orbit, do we enjoy the regularity and diversity of the seasons.

"If we draw a ribbon round a terrestrial globe, covering those parts over which the sun appears in the zenith, we isolate from the rest of the earth's surface a zone, the breadth of which is 47° including within it the *equator*. . . . . . This band has been called the *torrid zone*, from its constant exposure to an ardent sun; beyond it and on either side lie the *temperate zones*, the breadth of each of which is 43°; and farther north and south we find the *frigid zones*, with the poles in their centre distant from the temperate zones 23° 5′. Although this is an artificial division of our globe, it is nevertheless natural, for as the torrid zone is represented by a vertical sun, so the frigid zones are characterized by the partial absence of that

* Connexion of the Sciences, pp. 83, 27, 28.

† Astronomy, Cab. Cyc., American edition, pp. 185, 186.

luminary, while the temperate zones enjoy the happy medium of mean temperatures—there the incident beams fall at angles varying according to the season, and the sun never ceases to enliven the day.*

We should regret to close these secular evidences and explanations of the seasons without giving the substance of Professor Nichol's very perspicuous *rationale* of them, and the very delightful inference which he draws from their existence:—

"The variation of the seasons," he observes, "which in the old astronomy, it required many fanciful and complex notions to account for, is owing to an extremely simple arrangement. . . . . . It is obvious that if the terrestrial poles were perpendicular to its horizon there could be no seasons; for in whatever part of its annual orbit it might be found, the central luminary would shine over every part of it with the same relative intensity. . . . . . If, however, the axis leaned forward, or was inclined, the case would be wholly altered. . . . . . And if we suppose the axis to retain its position while the globe revolves in its orbital path, it is manifest that on reaching opposite sides of the sun, the southern and the northern hemisphere will be intensely heated in succession. Here, then, we have a change from summer to winter, and *visa versa;* and during the transition, the intermediate seasons of spring and autumn must have taken place. The change in question, then, is wholly owing to the inclined position of the globe's axis; and it must vary in degree with the amount of that inclination. Thus simple is the cause of such variations, and of all the exquisite adjustments with which they are connected. . . . . .

"On matters of this kind men feel variously; I confess that to me the sight of such exquisite adaptation, which shows such precision of workmanship, and stedfast solemnity of march, is as strong and eloquent a proof of the presence of the Godhead, as those deviations from ordinary agencies, which in the course of providence the Almighty has thought proper to produce; and that with a far loftier and more intelligent ardour than that of the Egyptian magician, we may exclaim, as we humbly contemplate, THE FINGER OF GOD IS THERE!"†

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* Introduction to Meteorology, pp. xix. xx.

† Contemplations on the Solar System, pp. 208, 209.

Before we conclude what we have to adduce in evidence and explanation of the "signs, seasons, days, and years," we would take occasion to remind our readers, that we have far higher authority for their permanency, in the immutable and gracious decree of Jehovah, to the present inhabitants of the world:—

"Neither will I again smite any more every thing living as I have done. While the earth remaineth, seed-time and harvest, and cold and heat, and summer and winter, and day and night shall not cease."*

After perusing the theorem and evidences which have been submitted, we must recal to remembrance what was elucidated at great length, and with much care, namely, that the obliquity of the plane of the equator to that of the ecliptic—on which the vicissitudes of the seasons so essentially depend—originated from a very peculiar quality in the primeval light, previous to its being concentrated around the sun, and when it was supposed to have impinged in a direction perpendicular to the plane of the centre of gravity of our system; and from thence putting forth energies peculiar to itself and in connexion with influences on the earth, generating a purely tangential force, *or rotation in planes at right angles to the line of its direction:* while it was, likewise, satisfactorily proved, that owing to the perfect equilibrium of the equipoising forces which maintained the earth in its orbital path around the sun, previous to its diurnal rotation, it could have resisted no other force capable of overcoming its inertia, than the one thus wisely and wonderfully brought to act upon it in lines perpendicular to its axis of rotation; and, certainly, when we are made thoroughly aware, that the obliquity of the two planes above mentioned, those of the equator and of the ecliptic, which proceeded from so recondite a cause, must have been known to the Jewish historian, at a time when none of the nations around had the most distant idea of it, but were in ignorance of this profound astronomical truth; and when we reflect, that the knowledge of a force, capable of producing motion at right angles to the

* Genesis viii. 21, 22.

line of its direction, has but lately dawned upon a surprized world, while both its existence, and the first and most stupendous effects produced by it, are implied and recorded by the sacred historian, so many centuries ago, we must become convinced, more firmly than ever, *that only in the divine record of the works of creation are to be found the base-lines of all real knowledge.*

Without dwelling longer than is necessary merely to allude to to the obvious fact, that the illumination of the sun, causing such periodical variations as "days and years," must have been observed by the inspired historian, *in common with every other of the earth's inhabitants;* and that he was most probably also acquainted with other less apparent and, consequently, less generally known phenomena; we shall pass on to remark, more especially, that the narrator of the first chapter of Genesis, whether he comprehended or not what he was writing, by the mere fact of having put on record the sublime truth, that the lighting up of the central orb of our system, or as it is therein expressed, "the setting lights in the firmament of heaven," should have been the immediate cause of "signs and seasons, days and years," makes known an implied knowledge *of the long continued non-rotation of the earth;* because, without including the *precession of the equinoxes,* which arose partly from the earth's protorotation, the comprehensive term of "seasons" cannot be considered complete. In the words of eternal truth there is nothing overlooked; there are no divisions of time too short; no periods, however protracted, which are too long to be disregarded; therefore, although the mutations occasioned by the *precession of the equinoxes,* are brought about in the course of many thousands of years,* yet they must have been as assuredly meant to have been classed amongst "the seasons," as were the minute gradations which denote the diurnal progress of the sun's rays on the revolving earth. Astronomical writers assert, that the precession of the equinoxes is owing, amongst other causes, to the protuberance, or excess of matter, at the equatorial regions of the earth; for, says Sir John Herschel:—

* *Seventh* Theorem, to which please refer.

"The immense distance of the planets compared with the size of the earth, and the smallness of their masses compared to that of the sun, puts their action out of the question in the enquiry of the cause, and we must, therefore, look to the massive though distant sun, and to our near though minute neighbour the moon, for an explanation of the precession of the equinoxes. This will, accordingly, be found in their disturbing action on the redundant matter accumulated on the equator of the earth, by which its figure is rendered spheroidal; combined with the earth's rotation on its axis."*

This excess of matter being wholly attributable to the condition of a sphere, which, after remaining for ages at rest, submerged in water, and having contracted repeated and numerous concentric layers of deposited matter encrusted around it, has been suddenly put into diurnal motion, we are authorized to conclude, from this closely linked chain of reasoning, that whoever asserted, for the first time, that the lighting up of the sun, and the reflection of its rays from the moon, caused "signs, seasons, days, and years," must necessarily have been aware of the earth's previous state of non-rotation, as this is clearly implied in the assertion, together with a knowledge of the actual rotatory motion of the earth, on which he dwelt, while he penned the announcement in question. Thus we are happily enabled to make the interesting observation, that those astronomical laws, certain as they have since been proved to be, whose announcement drew down upon Copernicus the derision of his more prejudiced and ignorant contemporaries, and the very truths for which Galileo was, in later times, accused before an odious tribunal, for which he was tried and condemned as an impugner of the Word of God, are clearly and legibly stamped by the divine historian, on the first of its sacred pages; and what may be considered still more remarkable, the same inspired amanuensis as clearly infers the more recondite, though no less certain fact, THAT FOR AGES PRIOR THERETO THE UNFORMED EARTH HAD NO ROTATION AROUND ITS AXIS.

With respect to what we have just been considering, that the sun and moon were empowered "to give light upon the

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* Astronomy, Cab. Cyc., American edition, p. 309.

earth," there is a very prominent inference which forces itself upon our notice, namely, *that no light had ever reached the earth before.* This, although an apparent contradiction, when we consider the stupendous works which had been performed through the instrumentality of the expansive principle emanating from the light, during the three days which had immediately preceded the one we now allude to, yet when tried by the principles established in the foregoing parts of this treatise, it will be found, to afford a most triumphant confirmation of the soundness of the views which have been adopted, and of the consistency of this portion of Scripture, whose every announcement registered a new law in nature's constitutional code.

What we assert, on the authority of the words pronounced on the fourth day, "to give light upon the earth," is, *that these were the first direct rays of light which ever reached the earth,* and that this assertion affords the most remarkable confirmation of the views formerly entertained; that the light of the *first* day, besides being of a different character from that of the *fourth,* was wholly expended in causing the rotation of the earth around its axis. That the expansion principle of the *second* day, likewise differing from sunlight, was employed in forming the firmament and in evaporating the waters; while that of the *third* day, similar in kind to that of the two first, was destined to perfect the atmosphere, separate the water from the land, and, latterly, to form the flowering and phanogamous division of the vegetable kingdom; and that the impartation of the light of the first three days was a permanent impartation, wrought into, and becoming for ever thereafter part and parcel of that which it contributed to complete.

And while this command affords such a convincing testimony to the rigid truth which pervades every line in this important portion of Scripture, it also affords a most wonderful conception of the wisdom and power of that Almighty Being, who could thus so exactly proportion the means to the end; that while wielding so subtile an agent, and performing such wonders with the light, he could so scrupulously measure out every iota of it, that not one should stray from the particular

design for which it was sent! A truth which will appear the more remarkable, when we ponder on the description of work performed by the light on the latter part of the third day; when, by its buoyant principle, objects so sessile as the grass which clothes the fields, were made to spring up upon its surface, and through the instumentality of the earth itself!

We have thus endeavoured to show, by these continuous enquiries, the close connexion which, in essential particulars, subsists between the subtile influences light and heat, the points in which they seem to manifest themselves separately being as necessarily implied by our hypothesis. We have exhibited the intimacy between light, heat, and electricity; and that, too, amongst the several kinds of this latter fluid. We have made manifest the similarity of electricity and magnetism, and the reflex influence which they exercise on one another, and the great probability that these, altogether, are merely modifications of the one comprehensive power, *expansion*, the all-pervading influence opposed to *attraction*. We have displayed the need, according to the previously prevailing laws, of such a power as this having been introduced into materialism, at the critical juncture it is announced, in order that it should, by overcoming the inertia of the earth and other spheres, cause them to rotate around their respective axis. We have striven to prove by the presence, on the one hand, of innumerable concentric layers of mineral matter around the exterior of the earth, which has been impressed with rotatory motion; and the absence, on the other hand, of these stratiform masses in the moon, which has not had diurnal movement communicated to it; that these concentric mineral encrustations, and also the saliferous waters in which they were immersed, were required as a commensurate leverage to produce diurnal rotation. While we beforehand took occasion to explain, how it was that these necessary stony concentric layers, could alone have been formed by deposition at the bottom of a dark and atmosphereless ocean, unknown to rotatory influences, and inhabited by the classes of plants and animals which science and revelation concur in showing did there exist, and could alone have produced the rocky accumulations which are now so highly inclined and tilted up

out of horizontality. And thus, link by link, as it were, we have been brought to a point which connects the whole with the first announcements of Scripture, that "In the beginning God created the heavens and the earth," that "Darkness was upon the face of the deep, and the Spirit of God moved upon the face of the waters," during the protracted but indefinite period of non-rotation, and, as a necessary consequence, we thus became prepared for the emphatic declaration which immediately follows:—

"And God said, let there be light."—

Thus rendering all our investigations subservient to the elucidation of the leading doctrines of the Dynamical Theory; that, assuming a condition of non-rotation, the introduction of the light caused diurnal motion, and consequently all the phenomena resulting from it, and from the pre-arranged material elements; that it was God, alone, who did all this; and that he has been pleased to reveal, for our information, the way in which his wonderful works were then performed.

There remains, now, one only source of evidence *in corroboration of the non-rotatory period of the earth's existence,* one apparently so disconnected, that were it not from reluctance to deprive any of the works of the Creator of its rightful share of the honour of supporting this recondite truth, we would be inclined to pass it over altogether. We allude to the formation—at the period to which we refer—of those creatures of the animal kingdom which depend on atmospheric air, and are fully *endowed with the faculty of locomotion,* whether their movements be restricted to the surface of the earth; whether they roam throughout the waters of the ocean; or soar into the aerial regions of the atmosphere, *provided they possess the power of freely accelerating and retarding their own motions and breath atmospheric air.* To cause objects so widely apart and so dissimilar to become evidences, the one of the other, will demand some exercise of our patience, and constrain us to run hastily through most of the intermediate links, in order to maintain that connexion which can alone carry conviction to the mind. In doing this, however, we shall have advanced, by the attention given to a great many of them in the fields of enquiry over which we have already passed, while

we would introduce what we may now have occasion to state with only one prefatory observation, but that a very important one. We allude to the remarkable difference between the *kind* of *light* employed to form the *animal* kingdom of locomotive faculties, and that which was used in constructing the *vegetable* existences. The light, which was made to enter into composition in the creatures of the fifth and sixth days, not only came from its present centre—the sun—but was made to pass through the seas and through the earth before it became embodied into animated existences. And in these respects it differed essentially from the light made use of during the first *three* days; and consequently must have produced different results, as far as it entered into the composition of the objects formed during these respective periods. The variation no doubt has some mysterious connexion with their living principle, or influence over their power to overcome attraction or inertia at will.

We shall, first of all, give a concise definition of the species of locomotion to which we allude:—

"Locomotion," say MM. Todd and Bowman, "is that function by which an animal is able to transport itself from place to place. It is enjoyed exclusively by animals; there being nothing analogous to it in the vegetable kingdom. But even, among animals, there are exceptions to the existence of this function. Many of them are fixed in their places throughout their lives; others enjoy the power of locomotion for a short period, but subsequently become fixed; while others again begin life fixed to one place, and are, at length, set free."*

And, in continuation, we shall seek to become acquainted with the "intimate connexion which exists between the power of accelerating voluntary motion and the function of respiration, action of the lungs, and the circulation of the blood," which constitute the subjects of the *hundred and thirty-eighth* Theorem; and then look into some of the evidences on which that theorem is founded.

"We have just explained," says Baron Cuvier, "the several

* Anatomy of Man, by MM. Todd and Bowman, vol. i. p. 67.

points on which all the vertebrated animals resemble each other. There are, however, certain differences which give rise to their separation into four large sub-divisions, or classes. These are characterized by the particular manner in which their motions are performed, or by the degree of their energy or vigour, and these again depend upon the quantity of their respiration. The nuicular fibres possess a greater or less degree of irritability and general energy according as the respiratory organs are more or less perfect.

"There are two conditions which determine the quantity of respiration. The first is, the relative quantity of blood supplied to the respiratory organs in a given time; and the second is, the relative quantity of oxygen, entering into the composition of the surrounding fluid. The quantity of blood purified by respiration depends upon the arrangement of the organs adapted for respiration and for circulation."*

Sir Charles Bell says—

"The function most essential to life is respiration; and the mode in which this is performed, that is to say, the manner in which the decarbonization of the blood is effected through its exposure to the atmosphere, produces a remarkable change in the whole framework of the animal body. Man, the mammalia, birds, reptiles, and fishes, have much of the mechanism of respiration in common; and there is a resemblance through them all, in the texture of the bones, in the action of the muscles, and in the arrangement of the nerves."

When treating of the circulation of the blood through the muscles, he says—

"There is one circumstance more which should not be omitted in the comparative anatomy of these muscles, as it exhibits another instance of conformity in their structure to the offices which they have to perform. We have just stated that the power of contraction is a vital property. The continued action of a muscle, therefore, exhausts the vitality; and to support that action, when it is inordinate, there must be a more than usual provision for the supply of this living power, viz., a means of increasing or maintaining the circulation of the blood, which is the source of all vital power."†

"The function of *respiration* in animals," say MM. Todd and Bowman, "is a very complex process, respecting the nature of which

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* Edinburgh Journal of Natural History, p. 24.

† Bridgewater Treatise, pp. 19, 121.

many unsatisfactory hypotheses had been formed. Until the law of the diffusion of gases, and of the permeability of membranes by them, had been developed, and until it had been shown that carbonic acid is held in solution in venous blood, no theory of respiration could be framed adequate to explain all the phenomena. It is now proved, that in this process, a true interchange of gases takes place through the coats of the pulmonary blood vessels, the oxygen of the air abstracting and occupying the place of the carbonic acid of the blood. . . . . . The presence of atmospheric air is necessary to the existence of all organized beings.* The air both passes by endosmoze into their nutritient fluids, and receives from them certain deleterious gases developed in their interior. The function by which the fluids are thus aerated is called *respiration*. . . . . .

"In animals, carbonic acid accumulates in the blood during its circulation; and when the atmosphere is brought to bear upon the capillary vessels containing the blood charged with this gas, a mixture takes place through the delicate walls of the vessels, the atmospheric air passing in, and carbonic acid, with nitrogen and oxygen, in certain proportions, escaping. Thus, the evolution of carbonic acid, and the absorption of oxygen and nitrogen, are the characteristic features of respiration in animals."†

Dr. Thomson assures us, that

"Without oxygen gas life could not be sustained. In it, unmixed with other gas, life flits away with greater rapidity than in common air; increased frequency of respiration is the immediate consequence, and disease of an inflammatory type follows, in consequence of the blood becoming more highly oxydized. (From Broughton—Quarterly Journal of Science, April, 1830). . . . . . According to Lavoisier and Seguin, an adult man consumes, by respiration in 24 hours, 46,037 cubic inches, or 32.5 ozs. of oxygen. Davy estimates the amount somewhat less, and Menzies slightly greater. . . . . . Boussingault (Annals de Chime) computes the consumption of oxygen by the horse in the same period at 13 lbs. 3 ozs., and by the cow at 11 lbs. 10.75 ozs., and so forth. . . . . . As we ascend, the atmosphere gradually decreases in density, and on lofty situa-

* This must be taken with exceptions; for example, the animals and plants living and growing at the bottom of the ocean, indifferent as to voluntary motion.—AUTHOR.

† Anatomy of Man, by MM. Todd and Bowman, vol. i. p. 3, 24.

tions the effects of its rarity are disagreeably manifested. Acosta, in the 16th century, described the violent symptoms which he and his companions experienced on the mountains of Peru; and very recently Dr. J. J. Von Tchudi, on the Cordilleras. Baron Humboldt at an altitude of 16,000 feet felt overcome with fatigue, blood burst from his lips and ears, and respiration was affected. . . . . .

"The brothers Gerard, in their travels among the Himalehs, frequently felt the inconvenience of atmospheric rarity. One of them thus describes his feelings:—'Our elevation was now upwards of 15,000 feet; here only began our toils, and we scaled the slope of the mountain slowly; respiration was laborious, and we felt exhausted at every step. . . . . . Long before we got to the summit we were troubled with severe headaches, and our respiration became so hurried and oppressive, that we were compelled to sit down every few yards, and even then we could scarcely inhale a sufficient supply of air. The least motion was accompanied with extreme debility and a depression of spirits, and thus we laboured for two miles.' Lieut. Wood (Journey to Sources of the Oxus,) at the Bam-i-duniah, or '*roof of the world*,' perhaps the most lofty *plateau* on the globe, endeavouring to break the ice on the Lake of Sirikol, to measure its depth, found that a few strokes with the axe exhausted his men, and continued work was impracticable. Mr. Green, who in September, 1838, ascended in a balloon to the height of 27,136 feet, the greatest altitude yet attained, felt comparatively little inconvenience, although the first 11,000 feet were ascended in seven minutes. This arose evidently from the almost absolute repose of the body. Mr. Green felt his respiration hurried only when he exerted himself.

"Captain Batten says, 'the feelings experienced by him on the Nitlee pass were far more severe than *Angina Pectoris*.' Moorcroft, (Asiatic Researches) describing an exploring expedition among the Himalehs, says, that 'his breathing was quickened and he was obliged to stop every four or five steps; he felt a sense of fulness in the head and giddiness.' . . . . .

"Mr. Lyell tells us, that the English greyhounds, taken out for the Real del Monte Company, in Mexico, when hunting at an altitude of 9,000 feet, where the barometer does not rise above 19 inches, were unable to bear the fatigues of the chase, and fell down gasping in such an attenuated atmosphere.*

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* The author has frequently witnessed similar results on other parts of the Mexican plateau.

"Dr. Martin Barry has given the following account of his own feelings on ascending Mont Blanc. 'At an altitude between 12,000 and 14,700 feet he experienced great dryness, in some parts a lurid colour, and constriction of the skin, intense thirst, incipient loss of appetite; at 15,000 there was exhaustion and difficult breathing, coming on suddenly after 20 to 30 steps, up a plane of 30° of indurated snow, having a slippery surface; these effects passed off on standing still and taking a few deep inspirations.'"

And to conclude on this subject:—

"On climbing high mountains," says Baron Liebig, "where, in consequence of the respiration of a highly rarefied atmosphere, much less oxygen is conveyed to the blood, in equal times, than in the valleys or at the level of the sea, the change of matter diminishes in the same ratio, and with it the amount of force availabe for mechanical purposes: for the most part, drowsiness and want of force for mechanical exertions come on; after every 20 or 30 steps fatigue compels us to a fresh accumulation of force by means of rest, absorption of oxygen without waste of force in voluntary motions."*

These ample and conclusive passages, supporting the theorem last mentioned, prove conjointly the indispensable necessity of atmospheric air for the perfecting of arterial blood, and the no less essentiality of this vital fluid for effecting voluntary motion; consequently the atmosphere was, and still is, absolutely necessary for the well-being, or even for the existence of all animals *possessing the power of movement at will;* for, as Sir Charles Bell emphatically expresses himself, in another part of the work already alluded to:—

"Any other hypothesis than that of the creation of animals suited to the successive changes in the organic matter of the globe, the condition of the water, atmosphere, and temperature, brings with it only an accumulation of difficulties."†

And more recently, Dr. Thomson expresses the same opinion by reasoning the subject negatively:—

"The influence of the atmosphere upon mankind," says he, "may

* Introduction to Meteorology, pp. 8, 14, 16, 19, 20.

† Bridgewater Treatise, p. 149.

be negatively considered; granting, for the sake of argument, that in its absence life could be sustained, upon the sense of hearing the want of an atmosphere would be tantamount to its occlusion; for, as sound is produced by vibrations in the air, none could possibly exist, the tongue would *then* be silent, and language unknown; the organs of smell and vision would no longer serve or afford us pleasure, for odours would be wanting; and excepting upon such objects as the sun's rays directly fall, all would be darkness!"*

In another part of this work it has been circumstantially proved, that the formation of the atmosphere depended upon the elaboration and evolution, during a succession of ages, of the constituent elemental principles, nitrogen or azote, and free oxygen; that these were produced by the decomposition of animal and vegetable substances submersed in water, which, in turn, was employed as a great reservoir to retain them in a proper state of preservation, against the period when they should be required, in order to be transformed into their present state in the atmosphere, by combination with the subtile principle of expansion or light; whose existence in the then condition of our planet would have been inconsistent with the great plan of the creation which was in progress of being developed; because it was essential, that *throughout the whole surface* of the spherical, non-rotating world depositions, layer after layer, from water, and encrustation on encrustation by animal agency and secretion, should have simultaneously taken place, before the globe itself should be in a condition, not only to aid the impetus originating from the primary light, in overcoming the inertia of the globe itself, but also to be in a proper condition to fulfil one of the chief objects designed by its rotation, namely—that the centrifugal impetus, which was engendered thereby, should have materialsp rovided, which that protomotion was to elevate and to transform into the present diversified earth, a spacious and suitable habitation for the very animals whose creation was to follow, and which we, at present, are bringing forward as examples, the last group of evidences, to prove the once entirely different state of this very planet.

* Introduction to Meteorology, p. 96.

It has been already sufficiently made manifest, that *wherever* organic remains are found, *there* life must, at one time, have existed. This axiom in natural history is so simple and so elementary, as scarcely to be worth insisting further upon; yet rudimentary as it is, by its dexterous application, we mean, at present, to substantiate two very important truths, namely, that it is scarcely possible to conceive, that the fossillized remains of testacea and zoophyta discoverable everywhere, and which abound throughout the mountains of the world, and on their highest ranges, could have been brought into existence, at first, or afterwards have come to maturity, *unless they had been submerged in water*, and far less so had they been placed on those scarped summits, beyond the overflow of the ocean, and left without an atmosphere—if it were possible to conceive such a state of matters—on some arid peak, unsheltered from the sun's rays, even by the intervention of the aerial ocean which now floats over all. And again, that as the existence of the shelly coating, now petrified, but once a serviceable though inflexible covering, proves the previous existence of a fleshy animal within, but which is no longer found in a state of combination; it follows, as a clear deduction, that the fleshy molluscous portion must have undergone decomposition, separation into constituent elements, and then exhalation, and that one of those elements must have been, and certainly was nitrogen or azote, an indispensable dilution in the atmosphere which now floats around and above us, and which tends so materially, by the oxygen it contains, to the sustentation of animal life, by aerating the blood, which, in turn, is the mainspring of all voluntary motion.

Light, as we have elaborately demonstrated, is as indispensable as any of those fundamental ingredients for the completion of the atmosphere. Without the addition of this buoyant principle to the other two more material ones, the light being, as it were, the life of the fluid mass, it could not have assumed its expansive condition; consequently it was as essential that, in due time, there should be light to combine with the bases, *nitrogen* and *oxygen*, as that there should have been those bases to combine with light, and, by their union, to constitute the expansion or "firmament," as it is termed in Scripture;

but then we have shown, by arguments equally well supported, that there are sound reasons for assuming that protracted ages of darkness were essential for the elaboration of the elements, attenuated as they are, which constitute the light or ethereal fluid itself, which was gradually expanding throughout the intermediate stellary spaces of the wide universe. That the introduction of light, or its completion, *before* the atmospheric principles had been stored up in the ancient ocean, before the primeval waters themselves had been properly purified, and the concentric stratified coatings of the spherical globe had been deposited and formed, would have been prejudicial to the plan of creation which was then in progress of being developed. That it was absolutely essential, agreeably to the known constitutional laws which the Creator saw fit to impose on matter—that, for a lengthened period, this sphere should be submerged in oceanic waters, and kept in darkness and quiescence until all those wonders—which were each to assume its place in the composition of the perfect work—had been completed in the capacious womb of nature, and that not until then did it accord with the plan of the Heavenly Creator to complete, or to introduce physical light into the material universe. It must likewise be borne in mind, that another and very important means employed in forming the atmosphere, was the violent agitation in the primeval waters, induced by the centrifugal impetus, arising from the first rotation of the earth around its axis. Nothing short of a commotion so general and penetrating as this protomotion undoubtedly produced, and which seems to have been essential, could have been effectual in combining the atmospheric ponderable bases with the expansive principle of light; and we would therefore wish it to be understood, that in "stretching forth the firmament as a curtain," the Creator chose to employ the impetus arising from the protorotation of our sphere—which, up to this period, had been encircled by a slumbering ocean, surcharged with gaseous elements—as one of the important agents which conspired to work out his will in this respect.

These conclusions enable us to point out the following indispensable requisites, agreeably to the established laws of matter, which entered into the formation of the atmosphere, namely, oxygen, azote, light, and violent universal agitation.

We have, at the same time, to direct the attention to the fact, that, until the atmosphere had been formed, no animal existences *possessing the full power of locomotion* could have been willed into being; because, as we have just seen, this animal movement depends upon the circulation of the blood; and this, in turn, on its due oxygenation by means of atmospheric elements. Here, then, we have the special conditions of the problem—free oxygen, azote, expansion, and violent agitation to constitute the atmosphere; and the record immediately thereafter, as to *time*, of the creation of innumerable tribes of animals *possessing the power of locomotion.*

If the four principal elements which we have just enumerated could, agreeably to the impressed laws of materialism, have been introduced into the universe, and brought into operation *simultaneously*, or, if rotation, and consequently centrifugal impetus, had not been inseparable from light, then we should have been unable to have availed ourselves of the recorded fact of the subsequent formation of the higher classes of the animal kingdom, as concurring testimony in favour of our fundamental assumption of *a protracted period of non-rotation.* But as we have already shown, at great length and with elaborate proof, that with respect to TIME, and according to the laws which it pleased the Creator progressively to impress on matter, *those elements could not have been, with the same results, willed into existence coevally*, we have by this means a fulcrum on which to rest the chief lever of our present argument; for there are elements in the constitution of the atmosphere (the atmosphere itself being indispensable to the higher tribes of animals) which indubitably required ages of darkness and of non-rotation to prepare, and render fit to be employed in the formation of the essential firmament.

The gaseous bases arising from the slow, successive generation of animal and vegetable existences, from their death, decomposition, and the exhalation of their component elements and peculiar secretions, required protracted ages of tranquil submersion and consequent non-rotation, before the primeval waters were in such a condition of saturation with them as, when thrown into sudden and violent agitation, they should produce results commensurate to the object required—before

an atmosphere capable of sustaining creatures with powers of locomotion, could have been so formed. But we have seen, that the ponderable bases of these gases constitute *part* only of the atmosphere. Of themselves, unassociated with the expansive principle of light, they could not have constituted the atmosphere as we now beneficially experience it to be. The introduction of light, however, *was*, agreeably to the laws established, *associated* with rotatory motion; and rotatory motion was inseparable from the violent agitation of the waters, and disruption of the strata, which in turn was inimical to the generation, extinction, and exhalation of animal and vegetable substances, in the manner and to the extent to which they were so necessarily required; consequently, although the buoyant principle of light was requisite for the completion of the atmosphere, yet, being as evidently prejudicial to the creation of its two chief elementary materials, free oxygen and azote, it could not, according to divine wisdom, have been introduced into the universe until darkness, tranquillity, and non-rotation had wrought out the designs for which they were, for ages, allowed to predominate over the surface of the shoreless waters.

It is from the fact of the indispensable concurrent and simultaneous presence of those elements for the construction of the atmosphere, contrasted with their no less certain incompatibility of co-existence in time; and shut in, on the other hand, by the evident necessity of the formation of an atmosphere, such as we and the more perfect tribes of animals now enjoy in common—before they or we could have been willed into existence, together with the announcement in Scripture, at the very juncture when all these elements were at one—that we deduce, from this source, *the most convincing argument in favour of a non-rotatory period.*

This incompatibility of co-existence as to *time*, and the necessity of being eventually brought into compatible union, so as to produce the end for which several of the elements had been so long preparing, constitute the bases of our argument, and enable us to conclude—*that the period of duration which intervened may be measured, by what was required to be done before the two converging lines could meet and be at one, in*

the formation of the atmosphere. A consummation, which, by the line of argument we have adopted, namely, proving the necessity of aerated blood for the motions of animals, is shown to be absolutely indispensable before the higher tribes of animals could, according to our ideas of divine wisdom and goodness, have been willed into existence; and such being so clearly the case, it seems evident, that the announcement on the part of the inspired historian, of those races having been willed into existence *at the period* recorded by him, implies that he was fully acquainted with all the previous phases through which the earth, in its creation, had passed; and amongst the rest, the protracted stage of non-rotation so indispensable for the generation and exhalation of the elements of the ethereal fluid, and also for that of the principal ponderable bases of the atmosphere.

We scarcely know whether this be a proper time to press upon the reader's attention an abiding conception which has been generated in our own mind, from the studies requisite to elicit the foregoing evidences; we shall, therefore, merely allude to it at present, in the hope that the future advancement of scientific research may either confirm or entirely disprove its reality; we mean, that according to the laws which it pleased the Creator to impress upon the works of his own hand, it became necessary, *before any beings, possessing the power of locomotion by atmospheric air, could be willed into existence, the pervading but opposing forces of attraction and expansion should travel in parallel lines, passing through and coming from the same central orb of each planetary system;* that previous thereto, or so long as those forces travelled in directions *oblique* to each other, there could have been no aeriation of the blood by respiration, no motion of the heart, no play of the respiratory organs, and consequently no voluntary motion. We do not mean to attempt any proof on so hypothetical an assumption as this at present is, but we do consider it to be a presumptive corroboration, that the concentration of the expansive principle, light, should have taken place around the central orb, the original centre of attraction of our system, *before any beings dependant on respiration for*

the aeriation of their blood and the animal force necessary to produce locomotion, were willed into existence.

We have premised that *this* is a mere fore-stretch of thought; but reverting to points thoroughly wrought out and elaborately established during the course of our work, we may terminate this closing part of our discourse with the following assertions:

That before the material light could overcome the inertia of the world, and cause the rotation of the earth around its axis, it was necessary that it should have been girded round, as it were, by layer after layer of stratified masses of mineral material, arranged according to a preconcerted order of superposition; and, that although, during innumerable ages, the submarine surface of this non-rotating sphere was extensively encrusted, not only by widely spreading masses of vegetation, but also by groups of living beings, diligently and submissively working out the designs of the omnipotent Creator, "God over all blessed for ever;" yet not one of the latter of these was possessed of either perfect gills or perfect lungs—in fine, *that there was not a single material being endowed with the faculty of free and full locomotion within the whole range of the solar economy, until after the spheres had been caused to revolve around their axes, the atmosphere had been formed, and the light had been concentrated around the sun in the centre of the planetary system.*

CONCLUSION.

PART I.

FROM "THE BEGINNING" TO THE TERMINATION OF THE GEOLOGICAL EVIDENCES.

The nature of the investigations which have so long engaged our attention confers peculiar importance on the concluding portion of this work, in which we shall endeavour to give a clear, concise, and continuous summary of what has been written: the more needful, as from the peculiarity of the subject, we have frequently been obliged to assume positions until, by undeniable evidences, others had been established which, in turn, should prove the soundness of those assumptions upon which we had been constrained, temporarily, to depend. The adoption of this method of procedure—in itself by no means desirable—having been rendered unavoidable, not only from there being no individual point standing out in relief, and thereby denoting itself to be the first link in the almost interminable chain, which might have been taken up separately and proved by itself, but because it likewise fell to our lot, to prove to the inhabitants of a world, accustomed to its diurnal rotation, that there was a long but indefinite period during which the revolving pedestal they tread on, though wheeled, as now, through space, had no movement around its axis; and that its protorotation caused the variety of hills and dales, continents and oceans, which now diversify its surface.

In the midst of doubt, as to the order of sequence which might enable us most effectually to explain these startling truths, we determined to follow, as closely as possible, that

which was offered for our guidance in the Divine Record; too happy, indeed, when in such perplexity, to have so unerring a guide to lead us through the embarrassments and difficulties of our undertaking. At the same time we laid it down as a fundamental rule, to avoid generalities, and to go into detail in bringing forward the scientific evidences which support our several positions along the whole line of argument.

Adhering to these two leading principles, and refraining from going back beyond a period debarred from finite creatures, but faithfully receiving what stands so clearly recorded, that there was a "beginning," when it pleased God to create the materials of "the heaven and the earth;" and believing, on the same authority, that the waters then *covered* them, for, "the spirit of God moved upon the face of the waters," we considered there was a mineral crust at the bottom of these waters; while—presupposing a non-rotating condition of our sphere, submerged, as it was, in the primeval ocean, and revolving in that state around the unillumined sun, by the equipoise of the same divellent forces which still govern its orbital motion—we assumed, in accordance with what we considered to be the implied meaning of the Scriptural Record, that the material crust at the bottom of the primeval waters, was tenanted by innumerable tribes of *living creatures without the faculty of locomotion in its full signification*, "the immovable creature that hath life," which were *not* willed into existence during the Mosaic week. The speciality of this command having led us to believe, that there was a *design of limitation in it*, and that the line was drawn where atmospheric air is indispensable to accelerate motion, our next care therefore was, to substantiate this fundamental position of all our future argument. It need not be thought surprising, therefore, if to this we dedicated a larger portion of our work, and have gone more into detail on this point than in most of the others.

That not a removable doubt might rankle in the mind to cloud the conviction, *we defined the whole animal kingdom, according to the Cuvierian classification;* and eliminating from it, by order after order, and by species after species, all those which *live and move*, in the full meaning of these terms, we showed, without attempting to trace the precise line of sepa-

ration, that there still remained a considerable residue which enjoy all the animal functions save that of *free locomotion*, accelerated at will by the assistance of atmospheric air. Consequently, that they could not have been comprehended in the creation of animals on the fifth and sixth days of the Mosaic week; and must, therefore, have existed previously. We next made it evident, that all such animal organisms are inhabitants of the water, and showed their adaptation, by the specific gravity of their shelly coverings and other concomitant circumstances, for being the tenants of the bottom of the ocean, and also their independency of atmospheric air.

The several lists of fossilized animal remains, discovered in the successive stratified formations, were then adduced, and a careful comparison having been instituted between them and the several classes of animals, obtained by the differential method which we adopted; the result was a close analogy between our *a priori* conclusions and the actual discoveries of geologists. By this we were enabled to apply the fact of their pre-existence, in explanation of the design which the Creator had in thus early willing them into being.

This we effected by showing, that their defective respiratory organs, on a par with their restricted faculty of locomotion, and the physiological development and functions of their internal structure, together with their method of depositing carbonate of lime, evidently manifested that plenary motion was denied them, in order, that while each was intent in encrusting itself with a coating of enduring calcareous material, their energies should be dedicated to the exudation of carbonic acid through the corium, which, in combination with calcium, unitedly assisted to form those vast calcareous stratified masses, which enter everywhere so conspicuously into the structure of the external shell of the great globe itself: that they were thus destined to leave indelible marks of having once existed in the strata, to demonstrate to all futurity, that the whole surface of the now rotating sphere was once submerged in the primitive waters—no other conditions of materialism, nor no other of its forms being accordant with the doctrine, *that the seas*, of our day, *did at one time simultaneously overflow every part of the surface of the earth.*

Having brought the evidence afforded by this division of the animal kingdom to a convergent point, which, as far as it went, conspired to prove, that there was a long but indefinite period of non-rotation; we left the general argument in that position until we should, by similar investigations, bring up the other concurring branches of testimony to the same point.

At liberty, therefore, to proceed with the general design, the next objects in the natural world which claimed our attention, were those plants which *do not* correspond to the description of "herbs yielding seed, or fruit trees yielding fruit, whose seed is in itself upon the earth," and which we consider to be the *cryptogamous* or *acotyledonous* plants, or plants very nearly allied to them. These we assumed to have been adapted for, and to have existed during the non-rotating period of the earth's submerged condition; and, for the same reasons, were not included in the command which, on the *third* day of the Mosaic week, ushered the other two divisions, comprising the flowering seed-bearing plants, into existence.

To substantiate this position, we first of all delineated, by Classes, the whole of the plants of which the *vegetable kingdom* is composed; then taking them, class by class, we showed, with minute attention to their botanical characteristics, to the physiological developments of their stems, and foliaceous appendages, their flowers, and other reproductive organs, that the *monocotyledonous* class corresponds precisely to "the herbs bearing seed upon the earth;" while the *dicotyledonous* division embraces as thoroughly and comprehensively, the "the fruit tree bearing fruit whose seed is in itself upon the earth;" and, consequently, whatever plants pertaining to the other division of the vegetable kingdom there may be which are not comprehended within these two classes of flowering, seed-bearing kinds, *they were purposely excluded from the command given during the Mosaic week;* this speciality in the divine record—a parallel case to that which occurred in regard to the animal existences—having proceeded from the fact of the others having been willed into existence during the protracted period which is termed in Scripture "the beginning," or previous to the formation of the light on the first day of the Mosaic week.

This assumption we endeavoured to fortify by showing, from the habits and physiological developments of similar flowerless plants, that they not only are of all others the most independent of sun-light and atmospheric air for their existence, growth, and reproduction, but are, likewise, peculiarly adapted for producing those effects, and accumulating those deposits, which seem to have been the object of their having been willed into existence.

We next turned to the actual experience of geologists and fossil botanists, who have described and classified the *mineralised flora* of the ancient world, with a view to compare their findings with our assumptions; and it was seen, in corroboration, that by far the greater portion of those beautiful and interesting vestiges of ancient flora belong to the *acotyledonous* class of plants, in strict accordance with what we had presumed, from the studied phraseology of that part of Scripture which narrated the formation of the *phanogamous* division of the vegetable kingdom.*

Having made sufficiently manifest, that plants, such as we alluded to, are either aquatic in their habits, or can exist submerged in water, and that they require, and must, from their gigantic proportions, have enjoyed the nurturing elements of warmth and moisture—we alluded to the fact, that their fossil remains are found imbedded in coal fields and other formations high above the sites of the present oceans; and from thence drew the direct inference, that being deeply entombed in elevated localities, far above the level of the present sea, and such not having been the elevations where they originally grew, increased, and reproduced themselves, in exercise of their vegetable vitality; that they, together with whole mountain masses, of which they formed the covering, must have been elevated to their present position by some general and commensurate force; and the evidences arising from those primitive vegetable remains, everywhere abounding over the surface of the terrestrial portion of our globe, from the polar

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* All this irrespective, of course, of those anomalous objects of both kingdoms, whose existence in certain geological localities has not yet been satisfactorily explained.—AUTHOR.

to the equatorial regions, we inferred, that the power which elevated them and their associated foundations to such heights, must have been both general and simultaneous, as geologists concur in pronouncing the formations in which they are discovered to be contemporaneous; while aware of only one cause, the protorotation of the earth, which could have occasioned this universal and contemporaneous effect, we concluded, that those flowerless, seedless plants were previously inhabitants of the dark and atmosphereless waters of the primitive earth; and were there, in conjunction with the inferior classes of animals, working out the all-wise but mysterious designs of the Creator.

Having brought the evidences from this division of our subject to a convergent point with the previous ones, we left them with the design of returning to show, that both the flowerless, leafless plants, and the apulmonic animals were alike diligently engaged in creating the *materials* of "the heaven and the earth."

Before proceeding any further in summing up the evidences, it may be well, in order to impress the principles which directed our reasoning more indelibly upon the minds of our readers, to place these, not in an opposing but in a different light from that in which they have now been displayed.

Having entertained the conception that successive creations of organic beings, animal and vegetable, took place during the period designated "the beginning," although no specific revelation has been made of their nature or extent, it appeared to us a perfectly legitimate, indeed a laudable endeavour, provided we employed *equal authority*, to discover the import of the general announcement, that "In the beginning God created" the materials of "the heaven and the earth." It occurred to us, as it must seem evident to all, that if we could find any portion of Scripture, equal authority to that which was to be analyzed, which detailed the parts of the animal and vegetable kingdom called into existence *after* the formation of the light, and compared these with the *whole* of the objects which are now known to compose these respective kingdoms of organic nature, and it was found, that any tribes of either *remained over, upon the scale, after the revealed portion of creations had been measured off*, that *these respective residues*

would, as a matter of course, *be the organic beings which were willed into* existence *before* the light was formed, or during the period termed "the beginning."

This, in a few words, is the principle which directed the elaborate, and often unavoidably protracted enquiries which we have had occasion to institute in so many chapters of the preceding work. We recognized, in the portions of Scripture which contain the announcements of the formation of the animal and vegetable kingdoms, *a manifest design of limitation*,* which, taken in connexion with our conception of successive creations during "the beginning," led us to apprehend, that this method of comparing the tribes formed during the Mosaic week, with the entire scale of each kingdom, would lead to exact and desired results. Consequently, upon the Cuvierian classification of the animal kingdom, and the illustrations of other eminent men who have gone into detail respecting the inferior animal tribes, we stretched out, as it were, the classes and orders comprised in the command of creation narrated in the 20th, 21st, and 22nd verses of Genesis, *and found unrepresented all those which are either fixed to one locality from the dawn of their existence, or move imperfectly and slowly, and are independent of atmospheric air.*

An enquiry into the usual localities, mode of subsistence, habits, and vital and physiological functions of animals so characterized, generally, afforded every reason to believe that they could have existed, and did exist prior to the Mosaic week, and when the earth was in its non-rotatory condition; whilst a comparison of the animal exuviæ found in strata belonging to those early ages, corresponded as nearly as the circumstances attending their collection and classification would warrant, with the previous assumption, that animal life was, in these by-gone times, restricted to beings independent of atmospheric air, and consequently limited in their faculties of motion.

A precisely similar line of argumentative examination was applied to the objects of the vegetable kingdom. The natural orders comprehended in the command recorded in the 10th, 11th, and 12th verses of the same book, being compared with

* Genesis, i. 10—12, 20—22.

the lists of the three great classes of those beautiful objects of nature, it was found, that the *flowerless, seedless plants* were not specified; and from the success which had attended our reasoning regarding the animal kingdom, which bore a strong analogy to these, we had no hesitation in concluding, that this exemption was entirely due to the fact of their pre-existence. A subsequent enquiry into their method of vegetating, their habits, and physiology, confirmed this assumption, and led us to believe, that the primordial condition of the earth was not more perfectly adapted to their existence, than their existence, increase, and even their decay, were conducive to the progressive formation of many of the concentric, stratified masses of the earth's crust.

Whilst a comparison of these supposed conditions of primeval vegetation, with the lists of the fossilized vestiges in ancient strata, afforded a satisfactory corroboration of the soundness of the assumption of their existence before the formation of the light.

Evidences bearing upon the electrical condition of the non-rotating world, and its influence in producing aqueous crystallization, we found to be more than usually difficult, in consequence of the comparative incipient state of scientific research into the nature of those unseen influences.

Nevertheless, persuaded of the unity of design and uniformity in the development of the work of creation, we ventured to apply a similar mode of reasoning to elucidate this more recondite branch of our general enquiry.

Persuaded of the common origin, if not the altogether identity of light, heat, and one of the kinds of electricity; and considering that two kinds, the *positive* and *negative*, are indispensable for producing a voltaic current, while this, in turn, is requisite to produce crystallization; and observing, by the sacred narrative, that one only of these influences, namely, the light, was called into existence during the Mosaic week, we concluded, according to the principle laid down, and hitherto successfully applied to the preceding points, that the other influence existed *previously;* and, that it was counteracted by a power adapted to the circumstances of creation during the non-rotating period.

The same reasoning led us, as a direct consequence, to the conviction, that the *principle* which is implied in the scriptural language by *darkness*, was the opposing influence to light or expansion. The evidences adduced on the subject confirmed that belief; and, by a parity of thought, it seemed evident, that while one of the electrical influences, attraction, was in full operation, and the work of creation was progressing towards a consummation which the Creator alone had predetermined, the requisite supply (a variable quantity) of the counteracting influence could be communicated by him alone; no determinate quantity of light and heat, as now dispensed to a perfected creation, being adequate to the requirements of that which was in progress. This doctrine, as it lies at the ground-work of all our endeavours to reconcile these two great sources of information, we took particular pains to inculcate, and make as intelligible as the nature of the subject would permit.

Assuming the light, of the first day of the Mosaic week, before it was divided from the darkness, that is, before it had its expansiveness conferred upon it, to be the ethereal fluid of modern science; and considering that it did *not* exist during the period of non-rotation; while, at the same time, we proceeded upon the assumption, that motion produced the counteracting influence to attraction; the next conclusion we came to on this subject was, that the motion would necessarily be propagated by means of the water which circumbounded the earth, and, we presume, all the other spheres respectively, of the system; a condition more obviously apparent when it is considered, that in the absence of the atmosphere and the ethereal fluid, *water* was the element of greatest exility in existence; and, besides, it circumbounded every other material substance; the earth, we *know* at least, having been surrounded by the aqueous element, for this is shown, alike, by the testimony of Scripture and science; and finally, on this point, we were led to conclude, that sensations, such as those proceeding from light, heat, electricity, &c., which, in the present economy are transmitted by an ethereal medium of inconceivable tenuity, and communicated to a nervous system of corresponding delicacy and sensibility, when transmitted by water, a medium

of so much greater density, would require, not only for their due perception and propagation, but also for the comfort, perhaps for the safety of the organisms which were to receive them, to have interposed a medium, or external covering of commensurate resistance and solidity. Indeed, so convinced are we of this, that, without incurring in the crudest anomaly, we cannot conceive organic forms, whether vegetable or animal, of the non-rotatory period, to have been enveloped in a nervous reticulation or moluscous covering; but, on the contrary, we recognize the necessity of that which came into contact with the more material vibrations of that era, to have been of corresponding density, whether of calcareous or carboniferous material. While it should be remembered, at the same time, that this predisposed arrangement of the material universe, which demanded for its perfection at that period, such dense material intervening media, was in part determinately so, for the very purpose of encrusting the bottom of the primary ocean with massive enduring forms, which, while they protected the fabricator within, should remain for ever an integral part of those stony layers and carboniferous beds, which were in due time to form the terraine and the useful portions of the habitable globe. The organic existences were, besides, assiduously extracting from the turbid waters around, those mineral elements, whose depuration left them more limpid and buoyant, and therefore better fitted to be transformed, by the introduction of light and its important consequences, into the pellucid seas of our day; the *position* of these encrusted organisms at the *bottom* of the primitive waters being as wisely ordained, as their labours were progressive and efficacious.

Having proceeded thus far with our argument, it became requisite to explain how it was, that the animal and vegetable existences, assumed to have been, as we have already repeatedly stated, the occupants of the earth's universal crust beneath the primitive ocean, were employed, by the augmentation of themselves, and by their peculiar secretions, in adding layer after layer to the earth's material shell; while they were no less diligently and beneficently extracting from the waters, those earthy and alkaline elements, which the strength of their chemical affinities would otherwise have retained. That they

were, in fact, a living agency interposed between the water and the earth to assist in perfecting both, by taking from the former that which was superfluous and would have hindered its completion, and bestowing it upon the solid part, which, without those successive increments, would not have been rendered fit for the future purposes of the Creator.

To bring an argument involving so many important conditions, in due time, to a satisfactory conclusion, it became necessary, at this stage of it, to take up positions so comprehensive, as that no room for doubt should thereafter remain to disturb or embarrass the understanding.

The first of these fundamental positions which we endeavoured to establish, was:—

That the materials composing the stratified rocks of the earth's outer crust existed in mechanical and chemical suspension in the circumfluent waters of the non-rotating world.* And we arrived at this conclusion by the following process of reasoning:—

That, according to the unanimous testimony of geologists, the stratiform rocks bear evident marks of having been deposited from water.

That, assuming the surface of the submerged, non-rotating sphere to have been a universal level, they could not have owed their origin either to the disintegration of other rocks, for there were no eminences, nor to deposition from springs, for none existed.

That neither did they issue forth from within the material crust of the earth; because, with equal unanimity, it is admitted, *that beneath the whole strata of the earth's surface there exists a base of solid amorphous rock,* which precludes the possibility of the stratiform masses having come from within.

And having thus proved, that their deposition took place from water, and having shut up all other sources, we then

* It may be necessary for perfect exactness to state here, that some of the more recent of these formations are considered to have proceeded from *debris* occasioned by the earth's rotation, and some more modern still, to be due to the effects of the Noachian deluge; but for a general argument the above proposition is sufficiently correct.—AUTHOR.

showed, by astronomical data, as rigid as the source from whence derived, that the whole terraqueous globe was precisely the same weight *after* the deposition took place, that it was *before* it commenced.

Having arrived at this satisfactory fundamental conclusion, while, at the same time, we inferred, from the predisposition of material elements to assume a state of equilibrium, that without some addition to those which were then in conjunction, and which addition should emanate from a source *beyond and above all that is material,* no progress could have been made in the development of the plan of creation, inert matter being incapable of increasing or retarding progress in itself, while the demonstrations just made would show, that nothing possessing weight or gravity was added to the terraqueous globe during the formation of the strata. And finally we concluded, as the result of those combined deductions, that the only additions which could have been made, in perfect accordance with those assumptions, were *aqueous crystallization, and animal and vegetable* VITALITY; principles independent of gravity, and possessing all the essential requisites necessary to disturb the chemical equilibrium of the primitive ocean, and to excite the deposition required, while of themselves they must have emanated directly from the life-giving energy of the Creator.

Departing, then, somewhat from this general statement, we closed in upon the case more immediately under consideration, and manifested with suitable detail, what were the constituent elements, few in number but of universal prevalence, which entered into the composition of the mineral masses of the earth's outer crust, and showed, although in a briefer manner, that they are capable of being dissolved and held in suspension by large quantities of water; and having fixed these points, we endeavoured to explain, how the mineral elements, thus suspended in solution, were abstracted, even in spite of chemical affinities, from the primitive waters, by the combined agency of animal and vegetable vitality, and of aqueous crystallization; and concluded this particular branch of our argument, by a somewhat elaborate comparison between these elementary ingredients, their presumed manner and order of deposition, and the actual results of geologists, who have

examined the stratified portions of the earth's outer crust, and have reported upon its conformation.

These evidences were considered sufficient to establish the previous assumption, that the static equilibrium of the primeval waters was disturbed, and deposition was produced by the conjoint agency of aqueous crystallization, vegetable secretion, and animal vitality; while the existence of the strata *evinced that these combined operations were carried on in water.*

We then proceeded further to assert—that wherever the shelly coverings of the testaceæ and zoophytæ are found to exist, and they are discovered everywhere on the surface of the globe, *there* they must have lived, have died, have decomposed, and become resolved into their original elements, during which they would send forth peculiar gaseous exhalations.

That one of the most persistent, and by far the most buoyant of those gaseous exhalations, liberated during this putrefactive process, would be ammonia; whose upward ascent (as, by virtue of its low specific gravity, it percolated the primitive waters) to reach the surface, would, by the peculiarity of its chemical affinity, be the means of disturbing those of several of the other constituent elements, and thereby of throwing down mineral materials, similar to those which constitute the strata of the secondary and lower tertiary formations.

Before this particular branch of our subject was exhausted, we endeavoured to show, that the simple and admitted fact of the animal and vegetable formations, deriving their subsistence, and the material of their increase from the medium by which they were surrounded, *rendered a succession of animal and vegetable creations indispensable;* supposing, with reverence, as we have always done, that the Creator respected the laws which constitute matter, inasmuch as each race, in fulfilling the design of its creation, would necessarily exhaust the primitive fluid of those elements on which it subsisted; a progressive development requiring a change of adequate physiological agency.

We likewise strove to make apparent, the admirable adaptation of means to an end, which is evinced in causing those living and vegetating objects to encrust the solid shell of the earth,

while they were fulfilling the destinies of their several natures, in constraining the animal division of them to construct extensive deposits of calcareous material in situations which rendered them not only serviceable for the future wants of man, but likewise the most suitable safeguards to defend the carboniferous deposits from the effects of the violent heat, evolved during the movement of the various mineral masses, *inter se*, on the first rotation of the earth around its axis; and in ordaining that carboniferous deposits should superabound towards the epoch of that important event in the history of the earth's formation, whereby immense volumes of gaseous carbon were, by being wrought into those vegetable forms, not only rendered innocuous, but stored up for the comfort and use of races which were thereafter to be created.

Not the least remarkable proof of the wonderful forethought which betokens the whole of God's works we pointed out, is observable in the *juncture when* those great coal formations were accumulated; constituting as they did partially, in detached localities, the last covering of the outer surface of the *non-rotating* sphere, they became more immediately entombed beneath the vast masses of mineral *debris*, spread abroad throughout the waters by the comminution and abrasion which took place when rotation was impressed upon the earth; this extended mineral envelope, which spreads itself over the coal measures unconformably, serving to confine and to condense the carboniferous gases which would otherwise have been lost to the coal deposits, and have rendered them unserviceable; and also have been positively prejudicial to those portions of the plan of creation which were in progress of development, by loading the atmosphere with life-destroying fumes, when races of living beings, dependant on the respiration of atmospheric air, as the sustainer and promoter of their faculties of locomotion, were about to be willed into existence.

We concluded the part of the section, which depended on evidences drawn from the testimony of scientific writers, by showing the adequacy of the description of animals, zoophytes, and plants, supposed then to have existed, to have performed the objects for which they were collocated; and summed up the whole, by a series of reasoning designed to prove, that

as those existences of the animal and vegetable kingdoms were adapted to perform those labours—that as the results of their having fulfilled their destinies everywhere abound throughout the whole extent of the investigated earth, whether in situations far removed both by distance and by elevation from the sites and levels of our present seas, while all the agents were undoubtedly inhabitants of the water, and the debris spread over the coal fields equally denote the presence when and where they were deposited, of immense masses of water no longer existing—so we are constrained to believe, in the existence of the only cause which is sufficient to explain all those concurring facts, namely, that there was a long but indefinite period, during which the earth had no rotation around its axis; that it was then universally covered by water, which furnished the requisite abode and sustenance for those races of animals, and descriptions of plants, whose remains, in whatever state they are found, assumed their present positions when the sphere, constituted as we have supposed it to have been, was first made to revolve around its axis.

In continuation, after adducing the necessary evidences, we endeavoured to explain, how the concentric stratified masses of the non-rotating sphere were formed at the bottom of the primitive ocean; and in doing so we affirmed, that the precise period, foreseen from all eternity, having arrived, and the last particle having been added to the concentric crust of the primitive globe, the Creator saw fit, in his infinite wisdom, to change entirely the surface of our planet, by breaking it up into a diversified combination of sea and land, hill and dale. In doing this we endeavoured to make manifest the causes which were put into operation to effect the elevation of those horizontal formations, from their original recumbent position; and, in combination with the primary amorphous masses, to transform some portions of them into continental chains and mountains, and to depress others into the oceanic hollows of the present terraqueous earth.

In prosecuting this important and arduous part of our subject, we commenced by assuming the extreme position:—*that it was the expansive influence emanating from* LIGHT, *when first introduced into the material universe, and divided from*

the darkness by God, the Creator, which caused the earth to revolve around its axis; and that it was the centrifugal impetus, arising from that diurnal motion, which was made the immediate agent to elevate the continents and mountains, and to depress the oceanic beds.*

After dedicating our attention to the investigation of the identity of light and heat, and showing the almost irresistible power of the *expansive* force which emanates from those subtile elements, we came to the conclusion, *that the introduction of light into the material universe, and its division from the darkness, at that particular juncture to which allusion has been made, was tantamount to the introduction of a new and influential force, and that it must have been attended by commensurate effects.*

Searching into the probable nature of those effects, we first of all established the position, that the same laws of *attraction* and *expansion,* which regulate the movements of every atom of matter around and on the earth, extend their respective influences throughout the material universe, and govern all the orbs of space; and consequent on this all-pervading law, we concluded, that *expansion,* which separates the motes which dance in the sunbeam, would, when proportionately applied, have driven asunder the spheres of our system, if the nicely equipoised forces which retain them, would have admitted of any increase of their orbital circles around the sun.

Having explained, thereafter, by relevant astronomical data, that the earth's orbital and diurnal motions are totally independent of each other; that so far from there being any necessity for their having commenced coevally, the *orbital* might have existed for ages before the *rotatory* motion, although it is physically impossible that the reverse could have been the case; we briefly explained how inconsistent it is with the nature of the equipoised divellent forces, which restrain the earth in its position in space, to infer, that the *expansive* force, emanating from the newly formed *light,* could have caused our

* Although the same cause would be co-influential over all the spheres of our system which have rotatory motion, we deemed it more prudent to restrict our argument to the earth we inhabit, and with whose geological construction we are acquainted.—Author.

planet to have receded one iota beyond the path which it pursued *ab initio* around the sun; that whatever orbit was assigned to it when translated in space, and before the central body of our system was illumined, that same circle it still performs. We next proceeded to enquire into the effects of *new forces* impinging upon bodies differently circumstanced with respect to their capability of resisting the concussion; and it was found, after a review of bodies variously circumstanced in that respect, that those, like the earth, which are incapable of sustaining any percussion on their axes, or incapable of retreating before the force brought to bear upon them, but at the same time *are free to revolve, would maintain their position while they defended their axis from concussion by revolving around it.* They would, in fine, perform the identical motion which we presume the earth to have done, when the newly-formed expansive influence of the light impinged upon it.

This important conclusion, so accordant with all our previous ones, having been so satisfactorily come to, it next became necessary, in the regular sequence of our theory, to enquire into the probable effects of this proto-diurnal motion of the earth upon the material and aqueous portions of its exterior surface, constituted as we have assumed it to have been towards the close of its non-rotatory period.

In conducting this new branch of enquiry, we considered it necessary, by a display of astronomical data, to establish the fundamental position, that the *protuberance* of the earth's equatorial region is directly traceable to the centrifugal impetus arising from its rotatory motion.

The effects of this force on a *sphere*, geologically constructed, as supposed, at the period of its protorotation, were next investigated with reference to mechanical dynamics; and it was found, by the strictest analogy, that the force in question would overcome the resistance of cohesion amongst the mineral masses of the earth's crust, cause them to fly asunder to a certain extent, and thereby relieve the axis from a pressure which it was not adapted to sustain, by transforming the non-rotating sphere into *a spheroid of rotation,* an indispensable change, but which the earth could only have undergone by the

breaking up and the elevating of its recumbent mineral masses, in accordance with what we have all along surmised.

Blending geological with mechanical evidences, as we approached nearer to tangible proofs, we first made manifest the insignificancy of the distances between the two circles represented by the inner and the outer surfaces of the earth's external crust, in comparison with the radius of the globe; thereby showing, that for all practical applications, in computing from the centre, either surface of the shell might be considered equi-distant. And this done, we next exhibited proofs illustrative of the fact, that the primary amorphous masses are of greater specific gravity than the strata; and applying to those two established data, a well-known mechanical axiom, "that weights of unequal gravity, equi-distant from the centre of gyration, when put into motion by the same centrifugal force, will be thrown to distances according to their respective gravities," we concluded, that the amorphous masses, being of more weighty material, would, on the first rotation of the earth, be thrown further from the centre than the less denser strata, although these latter overlaid the others, when the centrifugal impetus was simultaneously impressed on both, and that this would be found applicable to all zones of equal latitude.

The next point which claimed our attention, was one peculiarly apposite, namely, the contemplation of the results which ensued from the circumstance of two differently constituted zones, one a rigid mineral shell, the other a liquid hollow sphere, having been simultaneously put into rotatory motion by the same force. And we deduced strong confirmatory evidence in favour of the soundness of our original assumption, from the facts which attended them, namely, that the one, obeying the laws of liquidity, rushed from the poles towards the equator, and, as it assumed the protuberant form of rotation, preserved a perfect *horizontality* of surface; while the other, being under the same impetus, but less free to move, was constrained, by its rigidity, to break up into continental ridges and oceanic hollows, these assuming greater elevation and depression towards the equator, whose rugged asperities of surface were rounded off, to a certain extent, by the im-

mense masses of debris, silt, and sands, swept along by the primeval waters in their passage from the higher latitudes towards the equatorial regions—the combined effects of those different results proceeding from the same cause, being to diversify the earth with land and sea, with hill and dale; to transform the rigid mineral zone into broad and impassable barriers, which separate and confine those waters which once overflowed them; and to render the terraqueous globe a well adapted pedestal for the myriads of creatures destined thereafter to be wheeled through illumined space upon its surface—no stronger proof being found throughout the whole of this theory, than the wonderfully powerful and wise transformation of a dark, ocean-bound sphere into a terraqueous world, diversified with fertile lands and sparkling seas, by the application of the same force; and that force emanating from the light, which was so essential to the well-being and comfort of those races of living creatures about to be formed and endowed with the faculty of volition, and the means of applying that faculty to their own individual purposes.

Not satisfied even with this degree of proof, we proceeded to infer from what was established, that the different manner in which those two spheres, the *aqueous* and the *mineral*, conducted themselves, and the assumption, by the former, of the static condition of rotation, *with perfect horizontality of surface*, went to disprove and for ever, the supposition of *encandescence;* inasmuch as the water must have then been under the same laws which now govern it; and, likewise, the hypothesis of *fluidity in the mineral parts:* for then they would not have taken the form they now have, but would have accommodated themselves into a spheroid of rotation, with a surface *equally horizontal* to that which the aqueous portion has assumed; while the inference to be deduced from both is, that the water must once have covered the *whole* surface; and this could only have been done while the earth had no diurnal rotation; for the moment this movement was impressed upon it, the waters must have fled from the polar towards the equatorial regions, the continents must have been raised up, and the oceanic hollows have been sunk correspondingly down, and together have become the fitting receptacle and im-

passable barriers of the rushing primitive waters as they accumulated in the equatorial region.

Having thus disposed of the results which proceeded from protorotation on the surface of the earth, and alluding to those which occurred amongst the *mineral* portions in a general way, we next undertook to investigate, more particularly, the probable consequences of the centrifugal impetus arising from diurnal motion, upon the horizontal mineral masses, arranged in superposition, as we have supposed them to have been, at the bottom of the primeval ocean; and applying, in prosecution of this, the same mechanical rule to which allusion was made above, we came to the conclusion, that as the underlying, denser, primary masses obeyed the law thus brought to bear upon them, and retreated farther from the centre than the lighter strata, they would, in some cases, pierce through their superincumbent associates, in others they would be raised up in conjunction, and in many instances both of these consequences would partially take place: and the primary amorphous masses would penetrate, while, at the same time, they elevated the stratiform rocks along with themselves; and on reaching the height to which the motion impelled them, they would be found the one reclining on the shoulders of the other, and together stretched into lengthened irregular ridges, with conical projections throughout their whole extent. It is scarcely necessary to add, that in pursuance of the method laid down, we compared the theoretical conclusion with the announcements of experimental geologists, and ascertained, that such are precisely the conditions in which the rocky materials of the earth's crust are found to be; while the evidences of their having assumed those forms and relative positions after much movement, friction, and evolution of heat are everywhere apparent, geologically and mineralogically. "He spake, and it was done; he commanded, and they stood fast."

The attainment of this advanced position in the general argument, enabled us by interweaving the celebrated solution, given negatively by M. La Place, to the question of the possibility or otherwise, of the ocean ever again overflowing the earth, with the evidences everywhere abounding of *such having once really been the case,* to conclude, that the conti-

nents and islands could have been raised *only by one great and simultaneous impulse*, the centrifugal impetus arising from the protorotation of the globe; for what M. La Place, from the relative density of earth and water, pronounces to be impossible *now*, must, for the same reasons, have been as impossible *during any period of rotation*, or since the relative densities of earth and water have been what they actually are; and, consequently, that *protorotation* took place *after* the primitive ocean had deposited those stratified masses which reveal their submersion by fossilized remains; for only after it had been drained of its mineral elements, and these had been concreted into the various forms since discovered at its base, could the two bodies, *land* and *water*, have assumed that diversity of *specific gravity* which, according to M. La Place, ensures the stability of the present order of things upon the earth's surface.

By this method of gradual approach we reached the point where the evidences arising from *geological* and *mineralogical* investigations became available towards the further elucidation of our subject; and, under this division of enquiry, we *first* directed the attention to the necessary results which would ensue from the movement, *inter se*, of immense masses of *mineral* material rubbing against and passing one another, while all were in motion; some of them with enormous velocity. It was considered that a great amount of *friction* would be the more immediate consequence; that the evolution of intense *heat* would necessarily ensue from this; that, as there would be much *comminution* of mineral matter, so there would be formed an indefinite quantity of *debris* from rocks of diversified mineralogical composition, with great accumulations of *breccia;* and from the fact of these operations taking place under water, where the pulverization of immense beds of calcareous material was simultaneously being carried on, there would be concreted extensive *conglomerate* formations, by the instrumentality of heat, lime, and water, in combination with the *breccia* fragmentary system alluded to, and by these great surface movements, thus simultaneously brought into conjunction with one another.

By the adoption of these views of the consequences immediately proceeding from the abrasion of the mineral masses, put

into motion by the protorotation of the earth, was made immediately apparent the manifest design thereby evinced of bringing about a universal and immediate *cementing process*, which should firmly and imperviously knit together the vast mineral masses, into which the originally concentric stratified shell was broken up, when, by the centrifugal impetus of a world put into diurnal rotation, its component parts were thrown into multiform elevations, to constitute the terraine portion of the habitable globe, and to become the restraining barriers of the former circumfluent ocean.

The simple but comprehensive elucidation which the Dynamical Theory affords of the formation and important uses of those vast *cementing processes* of the earth—*the breccia and conglomerate formations*—offering one of the soundest tests of the correctness of the cosmographical views of the Dynamical Theory.

Continuing our investigations, with respect to the other more prominent and immediate results of *friction*, arising from the *motion*, *inter se*, of the mineral masses constituting the crust of the globe, we arrived at the conclusion, that the foci of those intense heats, induced by *friction* emanating from motion, would be situated in and around the central masses of mountain elevations; and merely so, because, to attain these elevations, the rocks occupying them had traversed the greatest space from horizontality, while they, at the same time, had encountered the greatest resistance.

This conclusion, which appears so evident by reasoning, *a priori*, we proved to be confirmed by the *geological* evidences and *mineralogical* structure of the primary amorphous nucleii of the mountain chains themselves, as well as by the fused and altered condition of the strata in contact with them; while the fact of their having been subjected, in common, to the effects of those intense heats while submerged in water, and unknown to atmospheric air, became equally clearly evinced by the analogy of their crystalline structure, when compared with the results of actual experiment.*

* See Theorem 101, and evidences. These experiments were performed by Sir John Hall, to whom we owe a debt of gratitude for this and many other valuable scientific labours.—AUTHOR.

The formation of *mineral veins* and *dykes*, their *general* direction, together with their lateral branchings, and overflowings on the surface, constituted the sequent points of investigation, and furnished the next proofs that they, too, emanated, by a combination of forces, from the *centrifugal impetus of protorotation; no others being capable, in combination with the heat excited, of irradiating universally fused mineral material, from within the body of the earth, in lines generally perpendicular to its surface, which no longer retains the concentricity of a sphere.*

It was made equally manifest, that a confirmation of this conclusion is to be derived from the formation and direction of *metallic* lodes and veins, whose every feature bears testimony to their being the immediate offspring of thermo-electrical currents of inconceivable intensity; while the undeviating straightness of their paths, as testified by examination, alike through granite, gneiss, clayslate, sandstone, and other description of rocks, proves beyond the possibility of doubt, that they must have darted from foci of thermo-electrical force *after* these several rocks, of distinct composition, had assumed their actual positions as component parts of the external shell of the earth *as it now is;* and, combining this *deduction* with the one previously made out, namely, that the *heat* arising from *friction*, which gave origin to those electrical currents, was evolved by the *first* rotation of the earth around its axis; we arrived at this further important conclusion, *that the earth assumed the identical form which at present it preserves*, as shown by the straight lines of the metallic courses *simultaneously with the originating of those thermo-electrical foci*, or *within twenty-four hours after it was caused to revolve around its axis.*

The establishing of this point—so important when applied to what we had already made out, as to the attainment by the earth of its static figure of rotation before the termination of the third day—enabled us to draw another conclusive inference corroborative of the Dynamical Theory, namely, that, by contrasting the brevity of the intervening period with the distance overrun by, and the immense volume of water which rushed from either polar region towards the equatorial zone, to com-

plete the figure of rotation, its impetuosity must have been irresistible, and its burden of debris, sand, and silt very great; while the deposition of those water-borne materials would be accelerated in proportion to their respective masses; the blocks and boulders being first strewed over the surface nearest to the places of their origin, modified in some respect by local influences; the finely comminuted sand and silt being swept onwards as far as the waters themselves, and assisting to round off, and to fill up the rugged acclivities necessarily arising from the augmented centrifugal impetus of the equatorial regions, where the recumbent concentric shell of the non-rotating earth was most shattered, and farthest thrown from the centre, that it might complete the figure of rotation.

At the same time, we took occasion to point out, that, as the waters rushed from either polar extremity towards their common equatorial centre, they would, naturally, by reason of the latitudinal differences of that newly-impressed force, perform a somewhat spiral movement, and carry with them, in that peculiar direction, whatever matter they held in suspension; and that, although it may be impossible to identify the rolled pebbles, sand, silt, or mud, which would be constrained to perform the greater spiral curve, and by *their* means to prove this westerly direction of the waters to their greater extent; yet, as the immense boulders and blocks can be identified with the mountain chains from which they have been torn, they will be found—wherever they have been so traced—to have been swept in a westerly course, from whichever side of it they moved onwards towards the *equator;* and thereby they will furnish additional testimony, not only to the correctness of the Dynamical Theory, which accounts for, and requires those phenomena to render it complete; but, likewise, they will afford evidence which cannot be doubted, that the earth, during the transit of those boulders, blocks, and travelled debris, *possessed the identical exterior form which it now does; for they are found embedded on its surface;* and, like nature's finger-posts, they continue still to point the course which their watery conductor took during the first rotation of their common pedestal.

Confirmatory evidence of a similar kind, as well as strong

testimony to the beneficence of the Creator, were deduced from the unconformable position of the groups overlying the coal measures, which, consisting of mechanically suspended debris, were assumed to have been deposited upon immense surfaces of accumulated vegetable matter, and while they protected these from being swept away by the rush of waters, and general commotion amongst the mineral masses, likewise covered over and retained their gaseous exhalations, confined their bituminous substances, and consolidated, by the pressure of their enormous weight, the vegetable surfaces into the great independent coal-measures of the present day; the depositories, alike, of our needful fuel, and the sources of our comfort, and of our national industry and wealth.

Having reached this point in the evidences, we were enabled to bring forward, in continuation, those arising from the concurring opinion of geologists, with respect to an evidently sudden and universal change which the earth is considered to have experienced in its geological structure, and in the character of the plants and animals which tenanted its surface at the precise epoch of its geognostic history, when this theory demands that such a change—characterized by its geological developments, as well as by the nature of its animal inhabitants, and of its vegetable existences—should have taken place. Previously it was a non-rotating sphere, everywhere surrounded by a dark and atmosphereless ocean of waters, and unknown to external light or heat; now it is a spheroid of rotation, diversified by land and sea, hill and dale, revolving around its axis before the invigorating light of the resplendent sun; and well might it be expected, therefore, to present a widely different geological structure, and to be the abode of races of animals altogether different from the former, and endowed with other and more important faculties; its surface being likewise covered by vegetable existences of a totally distinct character from the submerged plants of the primitive earth.

This closed the long and interesting list of evidences afforded by those sciences which have reference to the more intimate character and geological structure of the external crust of our planet, and to the vestiges of animal and vegetable formations

found embedded on its surface, and which we offered as irrefragible proof, as far as they went, to establish the fundamental doctrines of the Dynamical Theory—*the previous non-rotation of the earth during a period sufficiently protracted to admit of the deposition of its stratiform masses; and its subsequent rotation by means of the expansive impetus of the primary light;* and we shall resume and finish this summary in the concluding section which immediately follows.

CONCLUSION.

PART II.

FROM THE GEOLOGICAL EVIDENCES TO THE FORMATION OF PULMONIC CREATURES; THE CLOSING EVIDENCES IN FAVOUR OF THE DYNAMICAL THEORY.

TOWARDS the termination of the preceding part of this summary we had reached a point, which exhausted the evidences derivable from the geological developments of the earth's crust, and the organic exuviæ everywhere found on its terraine surface; but, presuming we might be able to acquire some further corroboration of the general assumption, *that the change in the external form of the globe, from a non-rotating sphere to a spheroid of rotation, was coeval with the epoch alluded to in Scripture, for the formation of the primitive light;* from the kindred and exact science of astronomy, we followed up the subject by enquiring whether, in reality, there is anything said by astronomers, which might lead to the conclusion, that a change of form, such as we have assumed, did become perceptible, about the period in question, by means of a perturbation thereafter in the motion of the earth amongst the other heavenly bodies of our system: and we found, that there is a cycle of extreme duration, the retrogradation of the equinoctial points, occasioned by the action of attractive forces upon the redundant matter accumulated about the equatorial regions; and that the rotation of the earth acts as a counterpoise to prevent this spheroidal shell of accumulated matter from causing the earth so to alter its intersection with the ecliptic, as ever ultimately to coincide with the plane of that circle. Those conjoint influences

tending to make the intersection of these two points to move, although in an extremely gradual manner, in a direction *opposite* to that of the diurnal and the orbital motions, requiring no shorter a duration than 20,984 years to perform the entire revolution of the ecliptic! While it is admitted by the concurring testimony of astronomers, that about 4,000 years previous to the Christian era, the major axis coincided with the autumnal equinox, *or was in adjustment.*

From the agreement thus admitted to exist between the epoch when those points, at the commencement of a period of such duration, were in adjustment, and that on which we inferred, on the authority of Scripture, that the redundant matter and rotatory motion alike originated, namely, when the primitive light was at first formed, we concluded, after some reasoning on the subject, that it is incumbent upon us to suppose, that the lengthened cycle of 20,984 years, now in progress, commenced the moment in which, *by the expansive influence of the light, the earth was caused to rotate around its axis*, and thereby to throw up, about its equatorial region, the spheroidal shell of redundant matter, already so frequently alluded to, and which is so clearly proved by Sir Isaac Newton's calculus to have been one of the causes of the precession of the equinoxes; a conclusion, the more likely still, when it is considered, that the counterpoising influence, rotatory motion, was called into existence by the same means, and at the same moment, by the creative power of God.

We asserted, that such a conclusion is far more sound than vaguely to imagine, that four thousand years before the Christian era, the earth had performed precisely, neither more nor less, a cycle of 20,984 years *after* it had assumed the form and had become a spheroid of rotation. And not only so, but to be thereby obliged to infer, that being aware of the cycle in question, the inspired writer had announced, in consequence, that light was first formed at the moment which exactly coincided with the conclusion of one and the commencement of another of those almost interminable periods! Between these two opinions there could not be, as we clearly showed, any motive for a moment's hesitation; and we, therefore, came to the final resolution, that as the change of form, which

astronomers are thus enabled to detect in the earth, in consequence of the peculiarity of its motion amongst its associated bodies in the solar system, and which is so intimately and directly traced to the influences of two phenomena, which we consider to have owed their origin to the formation of the light, really did take place *at the period, and in the manner recorded by the inspired historian.* The truthfulness of his assertions being thus attested in matters which are tangible to the senses, we considered it gave us a prescriptive right to insist, that he should be believed in those parts of his assertions which cannot be submitted to the test of *philosophical* reasoning, nor to the more positive testimony of the senses; but which, nevertheless, are equally true, namely—*that all is the work of God.*

To simplify, as much as possible, so complex an investigation as unavoidably we were led into, when endeavouring to solve the problem of the consequences, with reference to its outer crust, of a world being put into rotatory motion after having accumulated, for ages, concentric layers of mineral material at the bottom of its motionless circumfluent waters, we confined our observations exclusively to what we considered to have taken place amongst the masses which constitute the *solid part* of the earth. And, therefore, in the section which followed, and which we are now summing up, we found it necessary to direct the attention to those no less remarkable and important phenomena which were *simultaneously* taking place with regard to the *waters* themselves, which during the non-rotatory period, had overlain all those rocky mineral masses. It cannot be doubted, we made manifest, that the same force of centrifugal impetus which raised the continents and mountain chains, and depressed the oceanic hollows, threw the earth's exterior envelope of water far beyond its original distance from the centre, and caused it, in minute dispersion, to occupy, for a certain period, part of the space which is now filled by the entire body of the atmosphere.

In conducting this part of our argument, after alluding to the increased difficulties which beset our path, in consequence of the absence of any allusion to such a state of matters in the writings of others, it was assumed as a position, which can-

not very well be doubted, *that, for all practical purposes, in reasoning, the water might be considered as the uppermost and most flexible layer of the concentric crust of the non-rotating sphere,* and as such (the laws of liquidity being taken into account), would, when subjected to the revolution in question, comport itself accordingly.

Unlike the rigid mineral masses, however, by this very distinction of fluidity, the water would be constrained, by the centrifugal impetus, to perform simultaneously two distinct movements, one latitudinal, the other longitudinal. The former of these revulsions—that from the poles towards the equator, to complete the form of rotation in the aqueous portion—having been previously attended to, we were left at liberty to deal exclusively with the phenomena which would arise from the *longitudinal* motion, combined with the greater expansion from the centre, in obedience to the centrifugal force. We considered it undoubted, that the movements of so pliant a body, as a hollow sphere of water, would be almost uncontrollably affected by the movements taking place in the rigid mineral masses beneath; it being physically impossible, that the continents of the world should rise up so far above their original horizontal position in the concentric crust of the earth, or the oceanic hollows, on the other hand, to decline so much beneath the same level, without immense longitudinal ridges of water having been forced up by the continents, and corresponding volumes carried down along with the oceanic depressions; and thus the primitive water, besides being thrown into violent commotion by the rush with which it proceeded from the poles towards the equator, would be corrugated longitudinally into immensely broad and high waves, and into deep and spacious troughs or hollows.

This agitated and altered condition of the water being premised, and as far as possible proved by analogy, we next assumed that the expansive principle, emanating from the primary light, was that which was being employed by the Omnipotent as the agent of creative power, while he saw fit, on this occasion, to cause it to impinge tangentially upon the water; and having thus prepared the mind, we made manifest the perfect adaptation of those longitudinal aqueous ridges, resting as they did

upon immense continents of heated mineral matter, to produce quick and effectual *evaporation*, where vaporization was required; and the withdrawal of those portions, now constituting our seas, from the action of vaporization, where this was sought to be avoided. And, in continuation, we proceeded to investigate the more immediate results of the action of LIGHT upon those ridge-like elevations of the primitive water.

At the commencement, however, of this enquiry we were arrested by the remarkable circumstance, that while the component elements of *water* are exclusively *Hydrogen* and *Oxygen*, atmospheric air—the first of the great natural bodies which it pleased the Omnipotent to form after the protorotation of the earth—consists of nearly four-fifths of *Nitrogen;* and, consequently, this atmospheric constituent, *which could not have been derived from the decomposition of water, must have been abstracted from some other substance.* In this dilemma we reverted to what had been stated, respecting the generating of ammoniacal exhalations, in one of our previous sections, and pointed out the wise forethought manifested by the creation of those successive races of animals at the bottom of the primitive ocean; from the decomposition of whose bodies had arisen those plentiful supplies of *ammoniacal* gas, one of the chief exhalations from putrifying animal matter, now brought into requisition to supply the *nitrogen* of the newly-formed atmosphere, while we took occasion to allude to the remarkable arrangement which seemed to render it necessary, that myriads of apulmonic creatures should, for ages in succession, have lived and propagated, and by their death should have furnished a peculiar secretion, absolutely essential for the well-being of future races possessing entirely different organs of vitality.

We likewise pointed out the appropriateness of the juncture *when* it pleased the Creator to cause the two potential influences of *rotatory impetus* and *light* to be added to the bases of the firmament, thus previously and universally stored up in the primitive waters; these elementary bases, however abundant of themselves, being of no avail towards the accomplishment of that great work; we also showed that light and rotatory motion, without these elements to have acted upon,

would not have been of much more utility; the concurrent combination of all these having been required to form the atmosphere—while it was the precise period, neither sooner nor later, when these existed simultaneously, and were, for *the first time, brought into contact*, that the inspired historian records the formation of the atmosphere.

We availed ourselves of this position of our argument to endeavour to prove, the union of the buoyant principle of light with the radicle or bases of the atmosphere; for while we admitted the potency of the centrifugal impetus to conduce, by the agitation of the primitive waters, to prepare them for combination with light; yet we maintained, that centrifugal impetus *alone* could not have dispersed the elements, of the firmament, to a height of fifty miles above the surface of the primitive waters from whence they emanated; and, in verifying this position, we adduced the evidences arising from the modern discovery of the diffusion principle of gases, which causes each, even when several are admixed, to fill a space as if it were the only one present; and we coupled this with the well-known fact in practical chemistry, that no exertions, however great, have hitherto been able to separate the *buoyant* principle from the *radicle* of either constituent of the atmosphere, so as to solidify either of these—"God formed the atmosphere"—"the firmament is his handiwork"—no finite power can unmake it.

Following up the method laid down at the commencement, as regards the unfolding of our general argument, we next directed our attention to the uses, made by the Creator, of the atmosphere, which was formed at the juncture, and in the manner we have endeavoured to explain; in doing which we pointedly alluded to the predetermination so obvious, that *a determinate* order of sequence, independent of all other means, should be employed in creating and in completing the successive parts of the material world; every progressive development of the creation having been made instrumental, as a secondary cause, to effectuate, or to assist in bringing about some other more advanced step of the same general plan. Like one immense, well-proportioned, and harmonious design, as it is being unrolled, where *every successive portion*

is partly drawn forth by means of that which had just been previously displayed; in no stage of creation this leading principle, so demonstrative of infinite wisdom and of superintending design, having been more clearly evinced than in the formation of the great aerial ocean which surmounts the land and sea. No sooner, indeed, was it completed than it became an immediate and most effective agent, in the hand of the Creator, for separating, by *vaporization*, the water from the dry land.

The completion of this object by *vaporization*, and not by *draining;* the discharging of the surplus portion of aqueous vapour into the seas, of the present time, by condensation; the requisite addition, by this means, of *fresh water* to the briny ocean, whereby it has ever since been enabled to afford a constant and equable supply of moisture to the terraine portion of the world, without causing a wasteful precipitation of saline ingredients; the avoiding of denudation of the land of requisite earths and salts, which the *draining off* of the waters would have occasioned; and the prejudicial consequences of sweeping those earthy and saline materials again into the seas; we showed were some of the more prominent and important services which the newly-formed atmosphere was caused, by the wisdom and power of the Creator, to achieve almost as soon as it was stretched forth over the globe.

In order, primarily, to establish the *general* position, namely, that *vaporization* was *the* method which it pleased the Creator to employ in separating the water from the land, we premised the self-obvious fact, that any mass of water, universally encompassing a sphere, must be homogenous, either *all fresh* or *all salt.* Were we to assume that the primitive water had been fresh—that is to say, without having saline ingredients in solution*—we should be involved in endless difficulties, to explain, not only the present saltness of the ocean, but, likewise, the immense deposits of mineral salts of various kinds, associated with certain geological formations, found almost every-

* It should be remembered, that although the primitive waters held the elements of salt in solution, yet these, until the strata were deposited, having been in combination with neutralizing elements, the waters, as regards the plants and animals of the non-rotating sphere, may be considered not to have exhibited *saltness.*—AUTHOR.

where over the earth's surface, as well as to show, how it came to pass, that the land was not bared of its soil and of the loose vegetable substances so essential for its perfection; but when, on the contrary, we assume that the primary circumfluent ocean held saline materials in suspension, and take into consideration the concurrent elements which were present at the period of the earth's first rotation, and of the formation of the atmosphere for the promoting of *vaporization;* the almost inconceivable amount and dispersion of heat occasioned by the elevation of the continents and mountain ridges of the world; the great capacity of the *newly-formed* atmosphere, in addition to its inherent elasticity, for absorbing aqueous vapour; and the irrefragible, tangible evidence of the *solid salt deposits* which have been left behind, and which can be scientifically accounted for only by the supposed application of heat to water holding salt in solution; we showed, in fine, that when all these concomitant circumstances were taken into account, there was not the smallest room left to doubt, that *vaporization* was the method employed by the Omnipotent to "gather the waters together into one place," in order "that the dry land might appear;" when, in the significant language of another contiguous passage of Scripture, it is asserted that "these are the generations of the heavens and of the earth when they were created, and every plant of the field before it was in the earth, and every herb before it grew: for the Lord God had not caused it to rain upon the earth, and there was not a man to till the ground. But there went up a mist from the earth, and watered the whole face of the ground."*

Having thus established the appropriateness of the *juncture,* namely, immediately after the first rotation of the earth, when there simultaneously existed centrifugal impetus, and extreme degrees of heat underneath the watery ridges, and over the surface of the continental elevations, we next took occasion to point out that, *without the direct interference of a power over and beyond all that is material,* there could have been no such effect produced, as the "gathering together of the waters," by means of condensed aqueous vapour, buoyed up and wafted

* Genesis ii. 4—6.

along by the atmosphere, because, up to the period in question, there was no lateral movement known in the material universe, according to the forces then in existence, *the aqueous vapour would have descended, as it arose, in parallel, although oblique lines.* But, precisely when the aqueous vapour in the atmosphere was in equilibrio, between its *upward* tendency by centrifugal impetus, and its *earthward* declination by the supremacy of attraction, it pleased the Creator to impress movements of a lateral and congregative kind, whereby the aqueous vapour was formed and wafted along, in regions peculiarly adapted in obedience to the command—"Let the waters under the heavens be *gathered* together into one place, and let the dry land appear."

We took occasion, next, to point out the appropriateness both of the *period* and of the region with respect to this recently introduced motion. In doing so we particularly referred to the corroborating facts, that without lateral, free motion in all directions, there could have been no "gathering together;" without *aqueous vapour* there would have been no "*waters* gathered together;" and unless watery vapour had been extracted by *vaporization*, there would have been neither "dry land," nor saliferous deposits, so characteristic of the operations which then took place.

In conclusion of this portion of our labours, we made manifest, in confirmation of our position, that the newly-formed atmosphere was employed by the Creator to separate the "*dry land*" from the "*seas*." To do this we had only to consider the condition in which our globe then was—one, of which there is no record of its ever having been in before; a condition wherein it is likely never to be again—a world of water, thrown into uncontrollable motion in various directions; immense and intensely heated continental ridges raised up, and running nearly the whole length of the terrestrial axis, with cooler parallel zones of deep depressions, stretching to even a further extent; these inequalities of surface and temperature being alike conducive to the accomplishment of the same end; and more so when reference is made to the tangential direction of the primary light, skimming, as it were, the surface of the

agitated waters, and transfusing their elevated portions into aqueous vapour, to supersaturate the newly-formed atmosphere.

A convincing corroboration of this appropriateness of period, and the state of the creation at the time, so clearly indicated by the last quotation we made from Genesis, is also found in the effects which those inequalities of temperature would produce in the currents of air; for, while the heat-expanded columns of the atmosphere, carrying with them *aqueous vapour*, flowed rapidly from the continental parts towards the regions of the sea; there would be a violent *under* current, or rush of the *colder* portion of the atmosphere, from the oceanic hollow towards the rarefied or heated regions, above the continents, conducing alike to the acceleration of the *vaporization* then going on, and more especially to the facilitating of oxydation, so essential for completing the soils, by passing currents of air, surcharged with oxygen, over the metalliferous formations presented, for the first time, to their action.

Nor did these constitute all the parts of this admirable arrangement; for we likewise alluded to the suitable condition of the terraine surface for the passing of those violent oxydizing currents of air over it. Unclothed, as yet, by herbage or any sessile plants, the vaporization was allowed freely, and without impediment, to take place from the bare unprotected earth; and the "dry *land*" was thereby sooner separated from the "waters;" while the larger plants and trees, which would infallibly have been torn up by their roots, and utterly destroyed, *were not as yet willed into existence;* for there was not, until a day thereafter, an "herb or a plant in the field." By these facts we were made more clearly to perceive, not only the goodness and wisdom of the Creator, but likewise the evident manifestation of design, and the correctness of the juncture assigned by the writer of Genesis, for the putting forth of those acts of creative power, when "the waters" were "gathered together," and the "dry land" was made "to appear."

At this period of our argument, we endeavoured to unfold, the effective simplicity of the method adopted by the Creator for enabling the ocean, without detriment to its static con-

dition, to become, for ever after, the bountiful source of those continual supplies of aqueous vapour which are so necessary for the sustenance alike of plants and animals of the terrestrial portion of the world; than which there is perhaps no part of God's wonderful works more abounding with evidences of power and adaptation, together with proofs of his having caused one portion of the plan of creation to be conducive to that which was to follow. It was requisite, that without exposing the ocean to the certainty of a prejudicial precipitation of its saline ingredients, by the absorptive withdrawal of fresh aqueous vapour from its surface by the atmosphere, it should be rendered capable, by the instrumentality of that aerial body, to diffuse healthful and re-invigorating moisture all over the land; and to receive it back again, when charged with earthy and saline ingredients, to be re-absorbed, rendered wholesome, and again fit to be diffused over the face of the earth, to refresh the thirsty animals and plants, in a manner analogous to the circulation of their own internal fluids.

Impressed with these convictions we showed, that while the equilibrio of the primitive ocean was had in remembrance, and preserved by the grand yet simple method of causing the heated and elevated continental regions to separate the saline ingredients, of those portions of water which rose up along with them, from the pure water, by means of driving off this latter in aqueous vapour, the newly-formed atmosphere wafted it away, in obedience to the command of God. The sea was thus supplied with an excess of fresh water *beyond* what was required for its static condition; its salts were held in solution; and it was enabled to afford aqueous moisture to all on the land; while the *land*, itself, destined thus to be irrigated, was made the guage to measure the quantity of fresh water poured into the general reservoir! And we would ask our readers, as we did before, whether any method more effectual, more appropriate, or of greater simplicity could be imagined? While the vastness of the agencies employed, and of the works executed, leave no doubt as to their origin, or the arm, whose omnipotence could alone wield them; for who but the Almighty could mete out the waters of the ocean in the hollow of his hand! and measure with the utmost

precision the proportion of fresh water requisite to be added to the general mass.

Nor did we allow the opportunity to escape of pointing out the reciprocal action and reaction on each other of the three great divisions of nature—the atmosphere, the land, and the ocean. The perfection, respectively of these three portions of materialism evidently depending on the completion of all. The atmosphere would have been unavailing, as a medium for the circulation and diffusion of watery vapour, without a thorough separation between the "dry land" and "the waters," while these, in turn, although distinctly separated, would have been utterly incapable of exerting any benign influence upon one another without the common instrumentality of the aerial ocean, which, in healthful expansion, surmounts them both, and by its peculiar properties becomes the channel of communication, whereby, syphon-like, the circulation between them has been kept up and their destined equilibrium preserved; and when reflecting on the beneficent arrangement, which so strikingly characterizes this part of the Creator's work, we reminded our readers of the convincing corroboration which these views receive when brought to the test of the narrative given in Scripture; for the words demonstrative of completion, "*God saw that it was good,*" are not once recorded as having been expressed during the whole period which intervenes between the formation of the primary light on the *first* day of the Mosaic week, and that on which the "earth" and "seas" were separated from each other and completely finished on the third day;* during which eventful interval, the life-sustaining atmosphere was so far made, but not completed, until this was effected by the action upon it of "the land" and of "the sea."

This most remarkable proof of the celestial origin of what is narrated of the world's formation by the inspired historian, we took care to point out; and to impress upon the minds of our readers, that he must either have been conscious of these great truths in natural philosophy, or have been a mere mechanical narrator of them. If the former, we know that he could not have derived his information from the merely human in-

* Genesis i. 4—10.

telligence of the period when *his* books were written; and if unconscious, then, likewise, must the revelation have been made to him by the Creator himself.

To complete our admiration of such condescending goodness we showed, that we had only to contemplate the benign and providential forethought, which lodged such bountiful, and universally diffused supplies of moisture within the interstices of the aerial medium, whose tenuous structure adapted it for evolving and communicating that necessary moisture to every herb and plant, destined forthwith to be brought into existence on the broad surface of the land; while the embodying and solidifying of those very objects of the vegetable kingdom, at the particular juncture, constitute a no less striking example of the providence of God, and the manifest design whereby all parts of the creation were made subservient to that which should follow. In the woody fibre and foliaceous appendages of the vegetable kingdom, were locked up, in beautiful forms, and for useful and provident purposes, immense volumes of carbonaceous elements, which, if left free and unfixed, would have proved baneful to those races of living animals, designed to be so soon thereafter called into existence, to people the earth.

When we reached this point of our argument, which so manifestly fixes the period *when* the completion of the atmosphere, the land, and the sea took place; and when they began mutually and beneficently to act on each other, we immediately made the requisite application of it to the upholding of the *Dynamical Theory*. For we showed, with reference to one of our former sections, that as atmospheric air is absolutely indispensable for the growth, well being, and propagation of the *phanogamous* division of plants, they could *not*, by possibility, have existed *before* it was formed, or during the non-rotating period; and consequently that these plants, of whose influential presence—even to the degree of essentially contributing to the formation of the concentric strata—we have so many and such indubitable evidences, by diversified and widely spread fossil vestiges everywhere abounding, must have been of a description *not* phanogamous. They could not have depended on *flowering* or *seeding* processes for their propagation. And by

this avenue we arrived at the same conclusion which we previously had done, when on the evidence of Scripture we assumed them to have been of a description which bore neither "seeds," nor "fruits with seed in itself," but *cryptogamous;* though many may have varied, perhaps, in some respects from those which are now classed under the *third* natural division of the vegetable kingdom.

With this conclusion fresh on the memory, and having reminded our readers, that since the first rotation of the earth no event in its geognostic history affords the slightest foundation for supposing, that effects so stupendous as those which were then produced could possibly have been brought about; and, therefore, that we might found on this assumption any superstructure which it is capable of sustaining; we went on to show, from the evidence of the most scientific writers on botanical geography, the well-known existence of numerous distinct *floral foci*, consisting in their greater part of *phanogamous* plants; and, from the combination of those equally well established facts, we came to the ultimate and unavoidable conclusion, that as the *phanogamous* plants could *not* have existed *before* rotation and the formation of the atmosphere, and as they are now found located in distinct *floral foci* in all parts of the world, *the earth must have received its present form, and even its identical inflexions of surface, about the period of its first rotation around its axis;* this being the only event, known to have occurred in the world's history, which could have occasioned those inequalities of surface, which so clearly mark off the boundaries, and have transformed the earth into so many floral districts upon its terraine surface.

And thus we find, that while the boulders and blocks, the fragmentary debris, and the rolled pebbles which are strewn over and embedded in the soil, denote the greater outlines and principal land marks; the closely and everywhere interwoven mantle of phanogamous plants, discovered in distinct districts, fill up the interstices, not only in the material surface, but in the intelligent mind, leaving neither a blank on the one, nor a doubt in the other.

As an appropriate conclusion of this section we took a brief retrospect of its principal points, exhibiting that they all went

to prove, that after the formation of the Flowering division of plants, a very remarkable change took place with respect to LIGHT. During the three previous days it had been arranged so as to be capable of being imparted in the *varied* quantities requisite for the successive development of the several great parts of Creation: first, to cause the rotation of the spheres; next, to combine permanently with the bases of the atmosphere, and expand the aerial ocean; then, to unite with water, and raise aqueous vapour sufficient to fill the aerial interstices of the firmament with stores of moisture for both plants and animals; and, lastly, to be wrought up with carbonaceous matter and other associated elements into woody fibre, and foliaceous and floral appendages, to bedeck the earth with those beauteous and useful objects which cover its surface everywhere. But immediately after the primary LIGHT had accomplished these objects, by the wonder-working power of the Omnipotent; and when it became necessary, for ulterior purposes, that it should no longer be unlimited, and capable of being imparted in varying quantities; but, on the contrary, should, for ever after, be restricted to *measured supplies*, commensurate to the wants, and consistent with the well-being of those objects of Creation which were to be introduced, and to be endowed with the faculty of locomotion—the residue of the light was, by the power of God, concentrated around the middle orb of our system, from whence it was thenceforward to dispense measured and beneficent supplies of light and heat, sufficient to accomplish the subsequent plans of Providence, and to sustain whatever is dependant on these influences in their several modes of operation; the appropriateness of the juncture assigned, by the sacred historian, for this remarkable change in the supply and allocation of the light, being another and most convincing argument in favour of the divine origin of the historian's information. Nor did we forego the opportunity of pointing out the essential but mysterious difference between the *two kinds* of LIGHT employed in forming the *vegetable* and the *animal* kingdom, and drawing a suitable inference from that remarkable circumstance.

Continuing our endeavours to explain the *Dynamical*

Theory; and having by our disquisitions so far prepared the mind for what was to follow, while we laid up a store of well supported data which might be made use of when required, on entering upon another section, we declared our intention to make manifest, that during the period, the first three days of the Mosaic week, when all the works to which we have been referring, were made and completed, the *light* was *not* concentrated around the sun; and we premised, that startling as the announcement is, and difficult as the investigation may appear, it is neither beyond the sphere of sound reasoning nor of the influence of philosophic proof.

Assuming, then, the position we endeavoured to establish, that the earth was caused to rotate around *its* axis by the expansive influence of the *primary* light, on its introduction into the material universe, and its division from the darkness, we applied this truth to all the rotating spheres of our system; and, upon precisely similar grounds of argument, assumed, that they, too, were caused to rotate, *by the same influence,* around their respective axes. And, in continuation, we made it evident, by a chain of reasoning deduced from astronomical and mechanical sources, that while there was no *material* substance added to the central orb, when the light was concentrated around it; the sun, itself, has rotatory motion, and is, besides, the only source of the external light and heat enjoyed by the earth, the quantum of both received being in in exact proportion to the area described;* or, in other words, that these luminiferous rays are received by the earth from the sun on whatever side of that luminary our planet may be.

Such being the case, we reminded our readers of the mechanical axiom, *that equal forces acting in opposing directions, neutralize each other, and produce no effect;* and setting aside for a moment the consideration of the obvious fact, that a force proceeding *from* a body, though free to revolve, could never cause it to do so, we directed our chief attention to the other positions particularized, and from their combination deduced the conclusion, that considering the rays of light and heat, which come from the sun in all directions, to be equal

* Second Theorem.

forces, whatever their power may be, they never could, in the direction they now proceed, or from their present centre, have caused the orb from which they emanate to have revolved around its axis.

In corroboration of our argument, as regards the *direction* of the primary light, we next elaborately showed, that the one in which it impinges upon the earth, in proceeding from the sun, is the *least likely* to have caused rotation, as it comes into contact in a line *perpendicular* to the earth's axis, one, in which direction this latter could have resisted no strain whatever.

Having thus disposed of the *direction*, we next endeavoured to arrive at the same conclusion, by showing, that the *quantum* of *light* and *heat* communicated by the sun being *fixed* and *determinate*, neither could it, as now placed around that central orb, have produced the stupendous works which, under the direction of the Creator, it did perform during the first three days of the Mosaic week. Therefore, although it pleased the Omnipotent, during the brief period of these natural days, to make use of the primary light, as his chief agent, in combining with the material bases *which he created through an indefinite lapse of ages*, and thereby to constitute those works of creation which denote his wonderful wisdom and his power; yet, it was *not* the light, as now concentrated around the sun—from whence it is caused to dispense light and heat in measured and commensurate quantities for the wants and well-being of the world's inhabitants—which was made use of to produce those effects; the first and most stupendous of which, was the rotation of the earth and all the orbs of our system around their respective axis.

Throughout the whole of our treatise, and more especially at this part of it, we were careful to impress on the mind, that there was *nothing created* during the Mosaic week; the ponderable elements of the material world having been *created*, and completely so, during the protracted period alluded to by the words—"In the beginning."

In continuation of our previous line of proof, we explained that, consistently with the laws governing the orbital motion of the earth, it could not have resisted any force impinging

upon it either in the direction of its centrifugal or centripetal impetus, or of any point intermediate thereto, as such would, necessarily, by adding to that with which it was coincident, have deranged the just equipoise of the forces by whose divellent influences it circulates in space; and, consequently, we were thereby under the necessity of seeking out a force of so peculiar a description that, while it should come into contact with a non-rotating sphere revolving round another, in a line perpendicular to the plane of the orbital path of the former, it should produce motion at right angles to the direction in which the impinging force itself proceeded. And we showed, by an unbroken series of argument, corroborated by proofs from scientific writers, that *electro-magnetism* not only acts in this eccentric and peculiar manner, so different from all other known forces, but possesses many other of the desiderata sought; while it is remarkable for producing rotation at right angles to the plane of revolution in certain bodies when free to revolve, with which it is brought into contact.

From thence we concluded, that primary light, in the condition of *electro-magnetism*, was the secondary agent employed by the Omnipotent to cause the earth to revolve around its axis; that a modification of the same agent was united with the material bases of the firmament, and occasioned it to expand; that the same was made to combine with water to produce the aqueous vapour of the atmosphere; that it was it which was wrought up with carbonaceous ingredients into the vegetable kingdom of the third day; and, having performed all these wonders, it was the residue of the same Light which was concentrated, by the Creator, around the solid nucleus of the central orb of our system; and thus *changed in direction, and also in character, and regulated in amount*, it was caused to dispense those luminiferous rays perceptible by the organs of vision, and which are altogether different in their effects from those of the primary light, in manner similar to what may be witnessed during experiments wrought by scientific men, engaged in exemplifying the diversified powers of electro-magnetism, and who, after having caused it, in streams imperceptible to the eye, to produce many wonderful effects, by bringing the opposite currents into convergence and contact with some

intervening body, produce a light so brilliant and dazzling as to be equalled only in intensity by the splendour of the noon-day sun; while we have only to couple this corroborating circumstance with the reflection of how beneficent it was on the part of the Creator *to restrict and regulate the rays of light* BEFORE HE *produced any of those numerous creatures endowed with vision*, to be more than ever convinced of the appropriateness of the time, recorded by the divine historian, as that of its concentration around the sun; the critical correctness in *the periods*, recorded in the narrative of Scripture, when those wonderful works were formed being well calculated to strike the unbiassed mind with peculiar force, this under consideration not being one of the least of these: indeed, we have only to imagine the excruciating agony, not to say total destruction to the sight, which man and the animals would have suffered had this change in the *direction* of the light, and this restriction and *regulation* in its *quantity* been effected *after* they had been created, to be persuaded of the full force of the description of presumptive, yet corroborative proof, which we wish thus to bring forward.

It was at this juncture of our labours, that we undertook the apparently difficult task of accounting for the seeming exception of the moon, whose motion was neither altered nor accelerated by the introduction of the primary light, and likewise of applying it in proof of our present assumption. For, after showing that the moon must have had, *ab initio*, the same movement in space which it still has, we proved the fact of its having undergone no alteration in that respect, although the primary spheres of our system were caused to rotate around their axes; and offered this as one of the strongest of all testimonies in favour of our previous assumption, namely, that the *force* employed by the Omnipotent to bring about those stupendous events must have been *electro-magnetism;* and we arrived at this conclusion from the consideration, that as there are *two* forces only known which act by *election*, or according to the nature of the elements composing the bodies with which they come into contact, namely, *chemical affinity* and *electro-magnetism;* and it being evident, that the former could not have been the power employed, it must, consequently, have

been the latter, thus showing, that the Dynamical Theory receives strong confirmation, as well from those cases, which appear at first sight to be exceptions, as from such as are the more immediate consequences of the causes enumerated.

The anomaly of the moon's motion, so far from invalidating the previous evidences, having been made to illustrate, in a still greater degree, the main point of our whole argument—that the introduction of light into the material universe was the introduction of a new force, which acted by election, *and occasioned the earth, and all the other primary spheres of our system, including the sun itself, to rotate around their respective axis.*

This part of our treatise we concluded by endeavouring to trace the intimacy existing amongst the several descriptions of electricity, as well as their common identity with *light* and *heat;* thus omitting nothing which might contribute to confirm our opinion in the great truth, that those various electrical influences owe their origin to one great and general source, as the immediate secondary cause of all.

Having reminded our readers, that the rays of light, as *now* received from the sun travel in lines *parallel* to, but in opposite directions to the influence of *attraction,* which converge from the *periphery* towards that luminary; and that we are necessarily bound to consider the material portion of the sun to have been from "the beginning" the centre of the same attractive influences which it still is within the compass of its own system, we inferred therefrom, that as the light was *removed at the expiration of three days to be concentrated around the opaque material body of the sun*—from whence it now dispenses rays, travelling parallel to those of attraction, which *always passed through the sun*—the rays of primary light, or that of the three days referred to, which must then have crossed the lines of attraction *obliquely,* could not have produced the same effects as those do which we now receive from the central luminary; because, to suppose otherwise would be to conclude, *that* DIFFERENT *causes could produce the* SAME *effect.* Whereas, by travelling thus, during different epochs, in diverse directions with respect to darkness or attraction, the light *now* and the light *then* must have been different in *kind.*

After these questions, depending more immediately on philosophical evidences, had thus been disposed of, we *took* occasion to point out, that the *announcement* merely, on the part of the sacred historian, that by the illumination of the sun it became the cause of "Signs, Seasons, Days, and Years," to the earth and its inhabitants, necessarily proves, that his information was derived from the Creator; for it implied a knowledge, on the part of the ultimate communicator, of recondite astronomical truths not then known by man.

The obliquity of the plane of the equator to that of the ecliptic, the invariableness of the axis, the revolution of the earth around the sun, and the precession of the equinoxes, included amongst the "signs and seasons," which latter involves, in turn, a knowledge of the accumulation of redundant matter around the equatorial regions in completion of its figure of rotation; while this, again, pre-supposes the knowledge of a long period of *non-rotation*, during which that matter was being prepared in the form of concentric spherical layers, and whose first disturbance, by diurnal motion, threw it up into the forms of rotatory equilibrio. And that this, and all other investigated facts, go to prove, beyond the possibility of a doubt, *that the more narrowly these announcements of Scripture are examined into, the greater will be the conviction, that at every advanced step which science takes, it will find the inspired historian still in advance,* still leading the way and pointing onwards, not only to a better acquaintance with the fundamental laws which the Creator has impressed upon materialism, but likewise to a more perfect knowledge of His own BEING and glorious attributes; until, at length, the conviction is reached which alone can satisfy the human understanding, THAT THE CREATOR OF ALL THINGS IS THE AUTHOR OF REVELATION; AND THAT ALL THINGS, WHETHER BELONGING TO THE KINGDOM OF NATURE, OR TO THE KINGDOM OF GRACE, HAVE DERIVED THEIR ORIGIN FROM GOD, DEPEND UPON HIM FOR THEIR EXISTENCE, AND OWE TO HIM THEIR RESPONSIBILITY!

After this there remained only one section of the creation which we could bring forward, in evidence, to prove the non-rotating period of the earth, and the precise juncture when it

was caused to revolve around its axis. We allude to *those races of animals which possess the full and free faculty of locomotion*, and depend on atmospheric air; and which, although but apparently *remotely* connected with the non-rotation of the earth, yet, rather than that they should be unjustly deprived of a share in the honour of vindicating the truth of our fundamental assumption, we resolved to include them in the proofs which we had to adduce. In doing this, it became necessary to establish the immediate dependance which the faculty of *voluntary motion has on the circulation of the blood, and possession of the requisite organs of motion;* and, in turn, the immediate dependance of sanguinous circulation on atmospheric air; while, connecting the first and last of these together, it was shown to follow, *that without atmospheric air and the requisite organs there could have been no voluntary motion.*

In like manner we reminded our readers, that, by our own conclusions, the impossibility was shown of there having been an atmosphere, unless its elements had been elaborated beneath the ocean, and after a lapse of ages rotatory motion had been communicated, to cause the centrifugal impetus necessary to put the material bases in a proper condition to be united to the principle of light; and, consequently, although the world from the beginning abounded with apulmonic beings, there could not possibly have been in existence any creatures possessing perfect lungs or gills, or endowed with the organs of voluntary motion until the atmosphere was formed, whereby the blood was to be aërated that was to enable them to move voluntarily. And that by this avenue, as well as by all others previously pursued, we arrived at the same invariable conclusion, that this earth, on whose delightfully diversified surface we are revolving, day after day, with unconscious celerity before the cheering rays of the sun, has, in reality, travelled for ages (devoid of form and circumbounded by atmosphereless primeval water), in the same orbital path around an unillumined sphere, and unimpressed with diurnal motion; while, as a corresponding final application of all our labours, we came to the soul-satisfying conclusion, THAT, HAVING SUCCEEDED IN PROVING, BY WHAT IS TANGIBLE TO THE SENSES, AND BY EVIDENCES FROM THE WRITINGS OF THOSE WHO DESCRIBE

MATERIAL OBJECTS, EVERY PART OF THE RECORD SUSCEPTIBLE OF SUCH PROOF, *and having reference to materialism; we have a prescriptive right to call on all to yield implicit belief in that part of the Mosaic announcement which is beyond the limits of similar proof, although undoubtedly equally worthy of credit*—THAT GOD IS THE CREATOR AND MAKER OF ALL.

The undertaking in which we have been so long and so earnestly engaged is now about to be brought to a close. The cares and anxieties of so many years, experienced under such a variety of circumstances, are henceforward to take another direction, to assume another aspect, to go forth in the earnest desire, *that all our endeavours may, in some degree, tend to subordinate every imagination of the heart of man to the* WORD, *which is in reality, the only revealed or known* WILL OF GOD.

None, perhaps, are more thoroughly persuaded than we ourselves are of the imperfections of the work which we have just finished; or more alive to the responsibility of offering it in this imperfect condition to the world; but, with the candid confession that we have done our utmost, that we have striven prayerfully, conscientiously, and laboriously to render it as perfect as we could; we confidingly cast ourselves and the important cause we advocate upon the generous consideration of the public; and rely on the forbearance of those who, possessing superior attainments in any one of the numerous branches of science which have been referred to, might otherwise feel disposed to attempt to invalidate the general truthfulness of our deductions, by undue severity, in consequence of the detection of venial or inconclusive errors, which we fear—nay, feel persuaded—are to be found in almost every page. After this unreserved admission, the assertion we are about to make may appear strange; nevertheless, we hesitate not to affirm, that the more thoroughly what we have announced is examined into, is brought to the touchstone, and is wholly purified, the more stedfastly will its ultimate correctness be established, until, at length, it be admitted, *that the Dynamical Theory of the Earth's Formation contains the germ of a true and comprehensive system of natural philosophy*, whilst

one characteristic feature will, throughout be found strongly displayed by it—*an undeviating adherence to the great principles laid down at the commencement.*

From these principles, be the branch of science what it may to which we have had occasion to apply them, we have never shrunk, nor have we failed in subordinating all our deductions to them. They have been carried boldly and openly forward through every part of our work, and we have, at length, brought them out untarnished, corroborated, and strengthened by the exercise.

With these explanatory observations, and having now more direct reference to the introductory part of our treatise, we have to conclude, in language somewhat relieved from the restraint imposed upon us by the close reasoning required in the body of the work, that like travellers in an alpine country, and benefitting by the lesson which experience has taught in such cases, we have led our readers by a winding, but an ascending path, now in one direction, now in another, but turn whichever way we might, our progress has ever been upwards.

It is true, that in following the natural windings of our course, we have sometimes descended into hollows so deep, as almost to have lost sight of our ultimate destination; while, on other occasions, our steps have faltered on the verge of precipices, over which we have been constrained to pass, as onwards and upwards we pursued our way, in spite of every obstacle, resolved that, even step by step, we should press forward to reach the summit—the goal of all our labours.

And having gained this, what do we now behold? The whole work of creation—a glorious temple formed by the living God, laid out in vast, harmonious proportions, stretching far and wide and all around us; with its vanishing points leading up to heaven, and pointing, in every direction, to the great Creator! This is what we behold, and a rich reward it is for whatever exertions we have been called upon to make!

As the eye, from the eminence it has reached, scans the intellectual scene, far in the distance may be seen a sphere, surrounded by an atmosphereless sheet of turgid waters, revolving in darkness round an unillumined sun, and without any other motion than that which sweeps it through mirky space; without

hill, without dale, without light; an orb of black, dull water, wending its way, in measured circuit, through the obscurity of etherless heaven! What can be its destiny? Scrutinized closer and with more searching view it is soon discovered that, hidden under these dark and tremulous waters, the solid crust teems with peculiar *animal life*, and is covered, in many places, by sub-marine forests of *seedless plants;* the humble, but assiduous instruments whereby the Creator, by the same operation, is purifying the waters, and increasing the thickness and the consistency of the solid shell beneath, to wait his future purpose. The waters, too, when analyzed from time to time, are found to have become more limpid, and salter than before. And all the elements of this fair world which are to rise out of these preparations are being created, during a period which it has pleased Omnipotence to make known to us as "the beginning."

But "*the beginning*," and the slow progressive labours of *separation* and *assimilation* are about to close. *Time* and the work of *combination* are to commence. The period seen from all eternity, when "he rejoiced in the habitable parts of the earth," has arrived. And hark! A voice "louder than the pealing of many thunders" proclaims from the midst of the universe "Let there be light" . . . . . and "let it be divided from the darkness;" and lo! what a mighty transformation has, on a sudden, and by this first act of Omnipotent division, taken place!

The motionless watery-bound sphere, starting into newly-begotten life, rises from its slumber of ages, and, revolving around its axis, casts off its liquid cerements; and, bursting asunder the mineral crust which can no longer engirdle its expanded size, thrusts the rocky layers hastily up into continental ridges, towering mountain chains, and massive channel courses, firm, fixed, endurable, to restrain, for ever afterwards, the waters, which, rushing with impetuous haste towards the equator, would, were it possible, have there regained their former ascendancy. But He who bade them rise from under the ancient ocean had willed it otherwise, and even that uncontrollable rush of waters is made subservient to his will to become the instrument of his pleasure.

For, while yet these revulsions are taking place, the same Omnipotent voice proclaims, "Let there be a firmament in the midst of the waters, and let it divide the waters from the waters; and transfixed, by words which *will* materialism into its destined condition, the watery vapour and its gaseous associates, thrown, by the violence of the commotion, into upper space, returning not thence, they there remain, ready at his command, to convey the superabundant water from off the land, and carry it whithersoever he pleases.

Again it is audibly decreed, "Let the waters under the heaven be gathered into one place, and let the dry land appear," and the firmament hastens to fulfil its Maker's injunctions. The misty vapours rise in quick succession from the earth, "the waters under the heaven are gathered together" and are poured into the midst of the seas, and, thus withdrawn, they display the beauteous transformation which has been wrought beneath the rushing and agitated waters! for now the land stands out to view, a glorious earth, fresh from its Maker's hand, sending up the residue of the teeming vapours from the newly-formed soil, into the clear blue vault of heaven, unstained, as yet, by the breath of a living being, or the exhalations of a single plant!

The same resistless voice is again heard, in softer but more life-giving accents, "Let the earth bring forth grass, the herb yielding seed, and the fruit tree yielding fruit after his kind, whose seed is in itself upon the earth," and that which, before, was dull uncovered soil, and hitherto unproductive, responsive to the words, shoots forth in softest verdure, its variegated and attractive covering of "seeding plants and fruitful trees," in full perfection; seeds ripened for reproduction; fruits replenished with their kindred seeds—the whole a pleasing sight of varied shades and colours, forms and foliage.

But even these increase in growing splendour, when, with a power which nothing can resist, the Omnipotent calls in the scattered rays of pristine light around the central orb, to send it forth with concentrated and augmented force and radiance to the uttermost bounds of the system. Then the pure, spotless, yet untenanted earth, finished in all its loveliness, and glowing in the brightness of the sun's first rays, revolves,

in silence, before its Maker; displaying, at each turn, traces of such matchless beneficence and wisdom of design, that the attendant angelic host, anticipating mankind's adoration, unite in one melodious burst of praise, and "shout for joy."

Not long without a munden chorus. For soon the water and the soil are made to render up all that is within them of life-admitting and life-sustaining elements; and earth, and air, and seas teem with their respective denizens; each after his kind, all formed alike for life's enjoyment to the full extent of their restricted faculties.

Yet not a living creature amongst them all to comprehend the works, the ways, the word of God, their heavenly Father; not one to render Him intellectual praise! until it was resolved, in the immutable council of heaven, to make a creature "in the likeness and after the image of the Triune Jehovah;" and man came forth, made after that form and likeness, and by the inspiring breath of God, capable of holding communion with his Almighty Maker; of understanding the revelation which He has been pleased to give of his works; and of rendering up intellectual homage for all these blessings!

We have now to conclude. This glorious vista, the earth, which we have thus endeavoured to depict, is the temple which God has constructed, and where he is to be worshipped. The azure canopy overhanging it, like a gorgeous pavilion, was stretched forth by his hand; the sea is his, for he made it; he rides on the circle of the clouds, and flies on the chariot of the wind; and the earth itself is but his footstool. *They* all shall perish, but He shall endurably remain, the same yesterday, to-day, and for ever! Oh, then let us fall down in joyful lowliness before his throne, and casting this glorious crown at his feet, let us ascribe to HIM all honour, and dominion, and praise, world without end, for ever and ever!

APPENDIX.

THE ANIMAL KINGDOM.

The following is a Synoptic Table of the Animal Kingdom, according to the classification of the late lamented Baron Cuvier :—

ANIMALS, arranged in Four DIVISIONS, Nineteen CLASSES, and Seventy-seven Orders.

DIVISION I.—VERTEBRATA; arranged in Four Classes, and Twenty-seven Orders.	CLASS I.—MAMMALIA, including Nine Orders.			ORDER I. Bimana
				" II. Quadrumana
				" III. Carnivora
				" IV. Rodentia
				" V. Edentata
				" VI. Pachyderma
				" VII. Ruminantia
				" VIII. Cetacea
				" IX. Marsupiata
	CLASS II.—AVES, including Six Orders.			" I. Rapaces
				" II. Passeres
				" III. Scansores
				" IV. Gallinæ
				" V. Grallæ
				" VI. Palmipedes
	CLASS III.—REPTILIA, including Four Orders.			" I. Chelonia
				" II. Sauria
				" III. Ophidia
				" IV. Batrachia
	CLASS IV.—PISCES, including Two Series.	Series I. Osseous, including 6 Orders.		" I. Acanthopterygii
			Malacopterygii	" II. Abdominales
				" III. Sub-brachiati
				" IV. Apodes
				" V. Lophobranchii
				" VI. Plectognathii
		Series II. Cartilaginous, or Chondropterygii, including 3 Orders.	Branchiæ fixed	" VII. Sturiones
				" VIII. Selachii
				" IX. Cyclostomi
DIVISION II.—MOLLUSCA; arranged in Six Classes, and Fifteen Orders.	CLASS I.—CEPHALOPODA.			" Cephalopoda
	CLASS II.—PTEROPEDA.			" Pteropoda
	CLASS III.—GASTEROPODA, including Nine Orders.			" I. Pulmonia
				" II. Nudibranchia
				" III. Inferobranchia
				" IV. Tectibranchia
				" V. Heteropoda
				" VI. Pectinibranchia
				" VII. Tubilibranchia
				" VIII. Scutibranchia
				" IX. Cyclobranchia
	CLASS IV.—ACEPHALA, including Two Orders.			" I. Testacea
				" II. Acephala
	CLASS V.—BRACHIOPODA.			" Brachiopoda
	CLASS VI.—CIRRHOPODA.			" Cirrhopoda

THE ANIMAL KINGDOM.—Continued.

ANIMALS—(Continued.) arranged in Four DIVISIONS, Nineteen CLASSES, and Seventy-seven Orders.

Division III.—ARTICULATA; arranged in Four Classes, and Twenty-four Orders.	Class I.—ANNELIDA, including Three Orders.			"	I. Tubicola
				"	II. Dorsibranchia
				"	III. Abranchia
	Class II. CRUSTACEA. divided into two Sections.	Section I. Malacostracia, divided into 5 Orders.	Compound eyes placed on pedicles and moveable.	"	I. Decapoda
				"	II. Stomapoda
			Eyes sessile and immovable.	"	III. Amphipoda
				"	IV. Læmodipoda
				"	V. Isopoda
		Section II. Entomostrachia, divided into 2 Orders.		"	VI. Branchiopoda
				"	VII. Pœcilopoda
	Class III.—ARACHNIDA, including Two Orders.			"	I. Pulmonata
				"	II. Trachearia
	Class IV.—INSECTA, including Twelve Orders.			"	I. Myriapoda
				"	II. Thysanoura
				"	III. Parasita
				"	IV. Suctoria
				"	V. Coleoptera
				"	VI. Orthoptera
				"	VII. Hemiptera
				"	VIII. Neuroptera
				"	IX. Hymenoptera
				"	X. Lepidoptera
				"	XI. Rhipiptera
				"	XII. Diptera
Div. IV.—RADIATA; arranged in Five Classes, and Eleven Orders.	Class I.—ECHINODERMA, including Two Orders.			"	I. Pedicellata
				"	II. Echinoderma
	Class II.—INTESTINA, including Two Orders.			"	I. Cavitaria
				"	II. Parenchyma
	Class III.—ACALEPHA, including Two Orders.			"	I. Acalepha simple
				"	II. Hydrostatica
	Class IV.—POLYPI. including Three Orders.			"	I. Actinia
				"	II. Gelatinosa
				"	III. Corallina
	Class V.—INFUSORIA. including Two Orders.			"	I. Rotifera
				"	II. Homogenea

NATURAL ORDERS OF PLANTS.

List of the Natural Orders of Plants, given by MM. De Candolle and Sprengel, in the "Elements of the Philosophy of Plants," pp. 138—142.

I. Plants of a cellular structure. Scarcely proper seeds. Propagated by Sporæ.

Fam. 1.	Fungi	*a* Conyomici	*d* Gastromyci
		b Nematomyci	*e* Spongiæ
		c Goniomyci	*f* Myeolomyci
,, 2.	Lichens	5 Musci Hepatici.	True seeds, double sexual parts.
,, 3.	Algæ	6 Musci Frondosi	ditto
,, 4.	Homallophyllæ.		

II. Plants with spiral vessels and slits. True Seeds. The sexual parts not double.

Fam. 7.	Filices	
,, 8.	Pteroidæ	
,, 9.	Lycopodeæ.	Uncommon sexual parts
,, 10.	Rhizosperme	ditto
,, 11.	Naiadæ.	

III. Plants with sexual parts obvious, and of the usual form. The spiral vessels dispersed through the stem. The embryon unevolved in the albuminous substance. The number three prevailing.

Fam. 12. Aroidæ
,, 13. Cyperoidæ
,, 14. Grasses
,, 15. Restiaceæ and Junceæ
,, 16. Palmæ
,, 17. Sarmentaceæ (Dioscoreæ, Smilacinæ)
,, 18. Coronariæ (Liliaceæ, Amaryllideæ)
Fam. 19. Irideæ
,, 20. Hydrocharideæ
,, 21. Alismeæ
,, 22. Scilamineæ
,, 23. Orchideæ
,, 24. Museæ.

IV. Plants with sexual parts obvious, and of the usual form. Spiral vessels in concentric rings. The embryon more or less evolved. Numerical proportion variable.

A. Simple floral cover.

FAMILY	FAMILY	FAMILY
25. Stylideæ	31. Pipereæ	37. Laurineæ
26. Aristolochiæ	32. Strobiliferæ	38. Myristiceæ
27. Polygoneæ	33. Amentaceæ	39. Plantagineæ
28. Chenopodeæ	34. Urticeæ	40. Nictaginæ.
29. Santaleæ	35. Fricoceæ	
30. Thymeleæ	36. Protraceæ	

B. Double floral cover. Number five prevailing.

a Petals united.

FAMILY	FAMILY	FAMILY
41. Primuleæ	49. Convolvuleæ	57. Compositæ
42. Personatæ	50. Jasmineæ	58. Aggregatæ
43. Acantheæ	51. Gentianeæ	59. Valerianeæ
44. Bignoniæ	52. Contortæ	60. Cucurbitaceæ
45. Viticeæ	53. Sapoteæ	61. Passifloreæ
46. Labiatæ	54. Styraceæ	62. Caprifoliæ
47. Asperifoliæ	55. Ericeæ	
48. Solaneæ	56. Campanuleæ	

b Petals more or less free.

FAMILY	FAMILY	FAMILY
63. Rhodondendreæ	79. Ahorneæ	95. Dilleniæ
64. Epacrideæ	80. Sapindeæ	96. Tiliaceæ
65. Labeliæ	81. Onagræ	97. Hermaniriæ
66. Rubiaceæ	82. Salicariæ	98. Chlanaceæ
67. Umbelliferæ	83. Cruciferæ	99. Cisteæ
68. Saxifrageæ	84. Papavereæ	100. Resedeæ
69. Terebinthaceæ	85. Ranunculeæ	101. Ionidiæ
70. Rhumneæ	86. Polygaleæ	102. Caryophylleæ
71. Diosmeæ	87. Leguminoseæ	103. Portubaceæ
72. Berberideæ	88. Capparideæ	104. Aizoidæ
73. Rutaceæ	89. Gyttiferæ	105. Cereæ
74. Memispermeæ	90. Agrumæ	106. Loaseæ
75. Anoneæ	91. Geraniceæ	107. Myrteæ
76. Magnoliæ	92. Malvaceæ	108. Sedæ
77. Melæ	93. Buthnereæ	109. Melastomeæ
78. Malpighiæ	94. Ochneæ	110. Rosaceæ.

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